The Engineer

LONDON, FRIDAY, SEPTEMBER 19, 1941.

PUBLIC NOTICES

THE INDIA OFFICE, S.W.1

ORDNANCE MECHANICAL ENGINEERS

The India Office Invites APPLICATIONS for APPOINTMENT of the following as Instructional Staff for the training of Ordnance Mechanical Engineers in India :—

ONE CHIEF INSTRUCTOR, with experience as Head of Engineering Branch of Technical Education with M.Sc. or equivalent degree.

ONE SPECIALIST in PHYSICS with B.Sc. or equivalent degree with knowledge of optics or radio engineering.

TWO SENIOR and TWO JUNIOR LECTURERS with B.Sc. or equivalent degree, who should be physicists or specialists in mechanical engineering, preference will be given to those with knowledge of optics or radio engineering.

Pay of Chief Inspector, Rs. 1000-50-1200 plus £40 a month ; Specialists in Physics, Rs. 850-37½-1000 plus £30 a month ; Senior Lecturers, Rs. 700-25-800 plus £25 a month ; Junior Lecturers, Rs. 600-25-700 plus £25 a month. In addition, a bonus of one month or part of a month's pay for each completed year or part of a year's service in India will be given. Free conveyance to and from India will be provided.

Work is of the highest national importance and candidates need have no hesitation in applying for posts. Further particulars and application forms may be obtained from the SECRETARY, MILITARY DEPARTMENT, INDIA OFFICE, S.W.1. Final applications should reach the India Office by 1st October. 7770

EGYPTIAN GOVERNMENT

PUMPING PLANT, ELEVATED TANKS, ELECTRIC MOTORS AND CABLE NETWORK

Tenders are Called for by the Mechanical and Electrical Department, Ministry of Public Works, for the SUPPLY and ERECTION of PUMPING PLANT, ELEVATED TANKS, ELECTRIC MOTORS and CABLE NETWORK for Mohammed Aly Barrage.

Tenders should be submitted direct to the DIRECTOR-GENERAL, MECHANICAL & ELECTRICAL DEPARTMENT, MINISTRY OF PUBLIC WORKS, CAIRO, not later than Noon on the 9th December, 1941.

Copies of the necessary conditions of Tender and specifications can be obtained on application to the Chief Inspecting Engineer, Egyptian Government, 41, Tothill Street, London, S.W.1, against remittance of £1 10s. 0d. per set, which sum is not returnable. Copies of these documents are also available for scrutiny at the above address. 7767

CITY OF COVENTRY—WATER DEPARTMENT

APPOINTMENT OF ENGINEERING ASSISTANT

Applications are Invited for the POST of ENGINEERING ASSISTANT, at a salary (on General Grade 1 of the Council's salary scale) of £260 per annum, rising, subject to satisfactory service, by annual increments of £15 to £350 per annum (with the addition of a temporary cost-of-living bonus, which for salaries up to £300 is at the rate of 10 per cent., and in the case of salaries over £300 is 6 per cent. on the first £300 of salary per annum and 3 per cent. upon the remainder).

The appointment is to fill a vacancy on the permanent staff of the undertaking, but all appointments made during wartime are, under the Council's rules, to be temporary only and for the duration of the war, when the position will be reconsidered.

Candidates, who must not be over 40 years of age, must be competent surveyors, levellers, and good draughtsmen and should be qualified by examination.

The person appointed will be required to pass a medical examination, to contribute, on the approved scale, to the Superannuation Fund established by the Council under the Superannuation Acts, and to devote the whole of his time to the duties of the appointment.

Applications, endorsed "Engineering Assistant," stating age, qualifications, present occupation and experience, and accompanied by copies of not more than three recent testimonials, must be delivered at the office of the undersigned not later than Tuesday, 30th September, 1941.

Canvassing, either directly or indirectly, will be a disqualification.

NORMAN J. PUGH, Assoc. M. Inst. C.E., M. Inst. W.E.,
Water Engineer and Manager.

Council House, Coventry,
12th September, 1941. 7774

THE CONSERVATORS OF THE RIVER THAMES

APPOINTMENT OF TEMPORARY ASSISTANT DIVISIONAL ENGINEER

Applications are Invited for the POST of TEMPORARY ASSISTANT DIVISIONAL ENGINEER, in connection with the Supervision of Land Drainage Work on Rivers and Watercourses in Oxfordshire and neighbouring Counties.

The salary offered is £925 per annum, with allowance for use of own motor car.

Applications, stating age, qualifications, experience and appointments held, with copies of testimonials, should be addressed to the CHIEF ENGINEER, THAMES CONSERVANCY, DE BOHUN ROAD, READING, so as to arrive not later than Saturday, 27th September, 1941. 7766

UNIVERSITY COLLEGE, NOTTINGHAM

ASSISTANT LECTURER IN MECHANICAL ENGINEERING

Applications are Invited for the POSITION of ASSISTANT LECTURER in MECHANICAL ENGINEERING. Commencing salary £250-£300, according to qualifications.—Further particulars and form of application, which must be returned not later than Monday, 6th October, may be obtained from the REGISTRAR, UNIVERSITY COLLEGE, NOTTINGHAM. 7777

The Engineer

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IMPORTANT NOTICE TO ALL ADVERTISERS AND ADVERTISING AGENCIES.

Owing to further drastic limitations in the use of paper it has been decided to reduce the printed area of THE ENGINEER page as from October 3rd. The type space will be :—

12″ in DEPTH and 9″ in WIDTH, THE COLUMN WIDTH BEING 2¼″.

Therefore in future all blocks and copy should be supplied to suit the new dimensions, which are the same sizes as our contemporary "Engineering."

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

WANTED, MANAGER for New and Fully equipped Ironfoundry, Lancashire district, capacity up to 20 tons per week. Excellent salary and opportunities offered to really first-class and fully experienced man. Capable full control of labour, good disciplinarian. Knowledge of costing and able to give quotations. Give fullest particulars in reply.—Address, 7756, The Engineer Office. 7756 A

WANTED, a CHEMICAL ENGINEER, Accustomed to Designing Chemical Plant for a factory in the Midlands. State age, qualifications, experience and salary required. This information will be treated in confidence.—Address, 7761, The Engineer Office. 7761 A

SITUATIONS OPEN

IMPORTANT

Advertisers in Situations Open Column should make themselves acquainted with the terms of

STATUTORY RULES & ORDERS 1940 No. 877

RESTRICTION ON ENGAGEMENT ORDER

AN ASSISTANT CHIEF INSPECTOR REQUIRED for Supervisory Post in large Engineering Factory in Midlands ; must be technically trained and an experienced, capable organiser.—Write, stating experience in full, age, and salary required, to 7783, The Engineer Office. 7783 A

CHIEF ENGINEER REQUIRED by Large Company in North London to Supervise and Control both Mechanical and Electrical Maintenance, including Works and Buildings. Previous experience of a similar appointment essential. Applicants should be over 41 years of age.—Write, stating experience, qualifications, age, salary, &c., to Box 596, A.K. Advg., 4, Talbot Mans., Museum Street, W.C.1. 7759 A

SITUATIONS OPEN

CHIEF ENGINEER REQUIRED by Large North of England Engineering Firm engaged on work of high national importance. This position is a permanent one, carrying with it high remuneration and excellent prospects. Men between the ages of 30 and 45 who have had first-class Design and Engineering Development Experience in the Commercial Vehicle Industry, and are used to Designing for Flow Production Manufacture, should apply in writing stating age, experience, and salary required.—Address, 7784, The Engineer Office. 7784 A

ESTIMATING and CORRESPONDENCE ASSISTANT, male or female, with engineering experience, for works, North-West England, dealing with Turbo Plant and General Engineering. Good prospects. State age, qualifications, salary and when at liberty.—Address, 7768, The Engineer Office. 7768 A

PRODUCTION and PLANNING ENGINEER REQUIRED. Light Engineering A 1 Priority Work. Established group with six factories. Only first-class man entertained. State qualifications, terms, in strictest confidence, to Managing Director.—Address, P3521, The Engineer Office. P3521 A

OPPORTUNITY for INVESTOR Wanting Part-time or full-time Administrative Occupation in own district to earn substantial income by assisting in established business connected with engineering and allied industries. Capital £750.—Address, 7786, The Engineer Office. 7786 A

PERMANENT First-class and Progressive POST of exceptional interest NOW AVAILABLE in large Manufacturing Company desirous of extending, by direct technical inquiry, its knowledge of and contact with large variety of industries (engineering of all kinds and many others) which are actual or potential users of its products, largely distributed through merchant trade. It is intended to build up a small group of technical investigators under the control of the successful candidate, who will be expected to plan and supervise their work, in addition to conducting investigations personally. Applicants must have some established technical status (particular type not necessarily vital), possess energy and right personality for "mixing" and establishing new contacts, and be exempt from military service. Firm is engaged on work of national importance and Protected.—Address, P3524, The Engineer Office. P3524 A

PRODUCTION ENGINEER-MANAGER REQUIRED by old-established Engineering Works and Steel Foundry in Manchester area. This position is a permanent one, and offers an excellent career to the right man. Men between the ages of 30 and 45, with first-class knowledge and experience of Modern Production Methods, should write, stating age, experience, and salary required.—Address, 7785, The Engineer Office. 7785 A

PROMINENT CONTRACTORS REQUIRE Capable AGENT to Take Charge of Reconstruction Work in North-West area. Must be used control of men. Excellent prospects.—Address, 7696, The Engineer Office. 7696 A

THE MINISTRY OF AIRCRAFT PRODUCTION invites APPLICATIONS for POSTS as TEMPORARY ASSISTANT TECHNICAL COSTS OFFICERS in the Directorate of Contracts ; salaries from £300 to £520 per annum, according to qualifications and experience. Candidates must have up-to-date scientific rate fixing experience in the machining, fitting and erection of air frames, guns and gun mounting, gun mechanisms, site and general armament work, torpedoes, aero-engines or small repetition work.—Applications, in writing, to the SUPPLEMENTARY REGISTER, 4, Gt. Marlborough Street, London, W.1, stating whether registered at any office of the Ministry of Labour and National Service and quoting order No. M913/40. 7765 A

THE Post You Are Seeking May Not be Advertised in this Column, but do not lose the Opportunity of Bringing Your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for a cost of Four Lines, 4s.; 1s. for each Additional Line. There is no better way of covering so large a field for such a small charge.

TIME STUDY ENGINEERS, under 35, REQUIRED by Electrical Engineers in Middlesex ; must have knowledge of Speed, Effort, System of Rating (Bedeaux). Salary up to £7 per week.—Apply in writing, stating if registered at any office of the Ministry of Labour and National Service, to the SUPPLEMENTARY REGISTER, 4, Gt. Marlborough Street, London, W.1, quoting order No. M 1005. 7776 A

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CLASSIFIED ADVERTISEMENTS CLOSE
PRESS—NOON WEDNESDAYS

The Engineer

Annual Subscription Rates

(including postal charges).

BRITISH ISLES ...	£3	5	0	
CANADA...	£3	3	0	Thick Paper Ed.
	£2	18	6	Thin Paper Ed.
ABROAD	£3	7	6	Thick Paper Ed.
(except Canada)	£3	3	0	Thin Paper Ed.

"THE METALLURGIST."

This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER each alternate month. Next date, October 31st.

ADVERTISEMENTS.

The charges for Classified Advertisements are 1/- per line up to one inch—minimum charge 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

Postal Address,
28, Essex Street, Strand, London, W.C.2.

Teleg. Address,
"Engineer Newspaper, Estrand, London."
Tel., Central 6565 (16 lines).

SITUATIONS WANTED

ASSISTANT ENGINEER (30) DESIRES CHANGE. Seven years drawing-office, industr. plant installations and maintenance.—Address, P3527, The Engineer Office. P3527 B

ASSISTANT PRODUCTION MANAGER—Young ENGINEER and FOUNDRYMAN, experienced ferrous and non-ferrous casting and billet production, WANTS POST. Sound metallurgical knowledge.—Address, P3525, The Engineer Office. P3525 B

BUSINESS MAN, Age 50, General Engineering experience, SEEKS ADMINISTRATIVE or similar POST in London. Salary £400.—Address, P3517, The Engineer Office. P3517 B

CIVIL ENGINEER (42), Fully Experienced in large construction works, SEEKS NEW APPOINTMENT, preferably on work of national importance. Free now, having recently completed M.S. job.—Address, P3526, The Engineer Office. P3526 B

ENGINEER (35) REQUIRES POSITION. Apprenticeship and technical training; 12 yrs.' marine and mech. eng. experience; aero., D.O.—Address, 3523, The Engineer Office. P3523 B

ENGINEER (41) WOULD LIKE CHANGE. Good plate, structural and general engineering experience, commercial and practical.—Address, P3528, The Engineer Office. P3528 B

ENGINEER (O.M.A.), Considerable Experience design special plant, hydraulics, explosives, research, DESIRES POST duration.—Address, P3529, The Engineer Office. P3529 B

ENGINEER (46), B.Sc., Assoc. M. Inst. C.E., A.M. Inst. N.A., seagoing ticket, DESIRES CHANGE with position of responsibility on work of national importance; last 14 years' experience with chartered civil engineers, design and inspection of large dredgers and other floating craft, cranes, and harbour machinery generally.—Address, P3509, The Engineer Office. P3509 B

EXPERIENCED ENGINEER, with Long Training as general manager, SEEKS ADMINISTRATIVE POST; successful technical and commercial experience.—Address, P3487, The Engineer Office. P3487 B

GENERAL MANAGER and CHIEF ENGINEER (50), M.I. Mech. E., of proved commercial, technical and organising ability, with successful record, is now free to take up any suitable POST where business and economic production development is required. Has successfully controlled large and medium-size works employing male and female labour on Government contracts. Thoroughly conversant with M.O.S., Admiralty and M.A.P. contracts procedure. Highest credentials. Would accept a moderate salary for progressive post with good prospects on really satisfactory results.—Address, P3486, The Engineer Office. P3486 B

IF the Man You Are Seeking is Not Amongst those Advertising in this Column, a Small Announcement in the "Situations Open" Column will Quickly and Economically Produce the Right Selection of Applicants, at the same time Eliminating Waste of Effort, Waste of Time, and Waste of Opportunity. The charge is Four Lines or under, 4s.; each Additional Line, 1s.; Box Numbers, 6d. extra, which includes despatch of all replies.

MECHANICAL ENGINEER, Fully Qualified, university degree, aged 28, experience steam turbine design, SEEKS PROGRESSIVE POSITION, preferably development dept., any engineering branch; free to move.—Address, P3522, The Engineer Office. P3522 B

MILLWRIGHT CHARGE HAND DESIRES Better POSITION; 16 years present firm, used to installations and general maintenance.—Address, P3500, The Engineer Office. P3500 B

PLANT MANAGER.—Young MECH. ENGINEER, wide general experience all types of plant, SEEKS POSITION as Plant and Maintenance Manager [with Public Works Contractors. Colliery apprenticeship, experienced road, bridge, power station and material handling plant, home and abroad. University trained. Exempt military service.—Address, P3516, The Engineer Office. P3516 B

UNDER-FOREMAN or CHARGE-HAND BOILERMAKER (over military age) REQUIRES POSITION in Ship Repairing and Boilerwork. Excellent record and capabilities; steady; sober and reliable. Highest references.—Address, P3519, The Engineer Office. P3519 B

PARTNERSHIPS

REQUIRED, PARTNER with Substantial Capital, or Company to co-operate for Production of New Agricultural Machine. Colonial inquiries. Home orders awaiting delivery.—Address, P3530, The Engineer Office. P3530 C

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BUDENBERG RECORDERS

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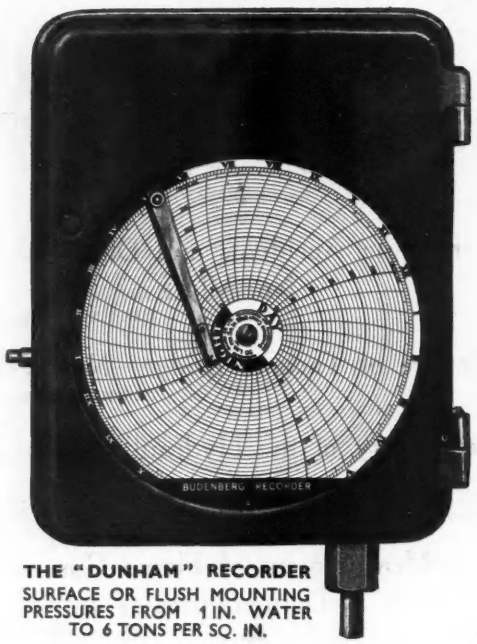

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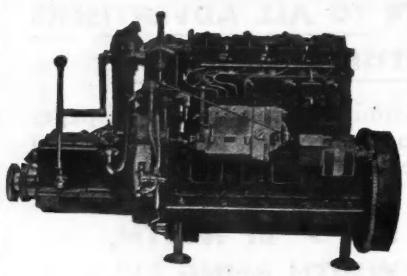

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Give to the Duke of Gloucester's Red Cross and St. John Fund—and give a little extra.

●

Contributions should be sent to the Fund at St. James's Palace, London, S.W.1.

Red Cross gratefully acknowledges free gift of this space.

MANUFACTURERS' CATALOGUES

"The Engineer" will be glad to receive catalogues, lists of manufacturers' trade names, etc., from firms for inclusion in the files of the Enquiry Department.

A Seven-Day Journal

Industrial Fuel Consumption

ON Thursday, September 11th, the Secretary for Mines announced that he had set up a Committee, under the chairmanship of Dr. E. S. Grumell, of Imperial Chemical Industries, to advise on the many technical aspects of efficiency and economy in industrial fuel consumption. The Committee is constituted as follows:—Mr. E. S. Grumell, D.Sc., M.I. Min. E. (Chairman), head of Fuel Economy Department of Imperial Chemical Industries; Mr. J. G. Bennett, Director of British Coal Utilisation Research Association; Mr. W. L. Boon, M.I. Mech. E., F. Inst. Gas Engineers, general manager of London and Counties Coke Association; Mr. W. J. Drummond, M. Inst. C.E., M.I. Mech. E., member of the Central Committee of the Mining Association and managing director of Ashington Coal Company, Ltd.; Mr. E. V. Evans, M. Inst. C.E., F.I.C., general manager of South Metropolitan Gas Company and Chairman of the Gas Research Board; Sir Clement Hindley, K.C.I.E., Past President, Inst. C.E., M. Inst. T., M.I.E.; Mr. R. J. Sarjant, D.Sc., Technologist of the Iron and Steel Industry (with Hadfields, Ltd.); Mr. F. S. Sinnatt, C.B., M.B.E., D.Sc., F.R.S., Director of Fuel Research of Department of Scientific and Industrial Research; and Mr. Johnstone Wright, M. Inst. C.E., M.I.E.E., chief engineer of the Central Electricity Board. The Committee will work in conjunction with a staff of combustion engineers who have been placed at the disposal of the Mines Department by the Coal Utilisation Joint Council. In addition, the advice of the Coal Survey Officers of the Department of Scientific and Industrial Research is being made available to the Committee.

Economy in the Making of Bricks

ON Tuesday, September 16th, it was announced that Lord Reith, the Minister of Works, with the agreement of the industry, has appointed a Committee, under the chairmanship of Mr. Oliver Simmonds, to advise him on the steps to be taken for increased efficiency and economy in the manufacture of bricks. The Committee is representative of all interests concerned and its terms of reference are, in particular, to advise on steps to be taken to secure adequate output, maximum co-ordination, pooling of resources and information, economy of manufacture, introduction of more scientific methods and on labour and transport problems. On the formation of the Ministry of Works a Directorate of Bricks was set up in October, 1940, to deal with questions of manufacture, supply and demand of all classes of bricks, excepting glazed and enamelled, and with wages questions in England, Scotland and Wales. Inquiries sent to 910 manufacturers showed 907 working 1184 yards at the outbreak of war and 634 working 825 yards at July 31st, 1941. Four hundred and twenty were members of associations or brick sections of local Chambers of Commerce and 214 were non-federated. The estimated output for 1941, based on production in the first five months, is 4500 million bricks. The Simmonds Committee will consider the substantial variation in production capacity per man, in methods of manufacture and drying, types of kiln, standards of equipment and organisation of yards; difficulties in supply of labour and fuel; and which firms or yards should be scheduled under the Emergency Work Order. Practice in many parts of the country is based on local and family traditions, and the industry, with notable exceptions, has not taken sufficient advantage of modern scientific knowledge and research facilities.

The Glen Affric Scheme Rejected

IN the House of Commons, on Wednesday, September 10th, the Bill sponsored by the Grampian Electric Supply Company, for the use of the Glens Affric and Cannich, near Inverness, for the supply of hydro-electric power, as outlined in the Grampian Electricity Supply Confirmation Bill, was, after a considerable debate, rejected without a division. The criticisms included the views that the scheme would jeapordise the natural beauty of two glens without any compensating advantages to the locality, and that the hydro-electric power thus obtained should be reserved for the development of the Highlands. In support of the Bill it was contended that the supply company was only seeking to fulfil its statutory obligations to supply electricity to an area in Scotland, and that the question of natural amenities had been exaggerated. Speaking for the Government, Mr. Thomas Johnston, the Secretary of State for Scotland, said that the principle to be considered was whether Parliament should give the supply company the powers it sought, or reserve its decision as to the development of hydro-electric power in the Highlands until the possible post-war requirements of the area were better estimated, or the Government was in a position to produce its own schemes for the co-ordination of hydro-electric resources in this country. There was no necessity, Mr. Johnston said, to assume that Parliament would delay until after the war its decisions on the future planning of other natural resources such as water supply, gas undertakings and the location of industry. These schemes, he continued, were now in preparation and it was possible that an announcement would be made within the next few days. In view of the issues involved, he advised the House to accept the motion for the rejection of the Bill on its second reading, which had been moved by Mr. Keeling. In the course of further debate it was revealed by Sir G. Courthope, who spoke for the Forestry Commission, that the Commission had not been consulted as to the merits or the demerits of the scheme. The Commission had, he said, in addition to being under a statutory obligation to provide for future timber supplies, to provide as far as possible for public amenities and public recreation in connection with its timber enterprises. Shortly before the war the Commission had visited the glens in question and had decided that certain areas were suitable as forest areas. If the proposed scheme were carried through the works would render the area unsuitable for the Forestry Commission's proposals.

The "Halifax" Four-Engined Bomber

ON Saturday, September 13th, details were released by the Air Ministry of the Handley-Page bomber, which, together with the "Stirling" and other types, forms the spearhead of the Royal Air Force offensive on Germany. The "Halifax" is an all-metal mid-wing monoplane, having a wing span of 99ft. and a length of 70ft., with a height of 22ft. It is powered with four Rolls-Royce "Merlin" twelve-cylinder liquid-cooled engines, and has three-bladed air-screws. The fuselage is rectangular in shape and the position for the bomb aimer is arranged under the forward turret. It carries heavy defensive armament and is furnished with slotted flaps for the purpose of giving improved take-off. De-icing equipment is fitted, not only, as usual, to the wings but to the tail unit and to the airscrews. It is mentioned that points in the construction which may assist identification include square wing tips, and a rectangular tail-plane with the twin fin and rudder units at its extremity. During last week Lord and Lady Halifax visited a Southern aircraft factory, and Lady Halifax, who a few weeks ago launched the thousandth bomber from a certain American aircraft works on its way to England, performed the naming ceremony for a new Halifax bomber. In a speech made by Lord Halifax reference was made to the part that that type of machine had recently played in heavy bombing attacks on Berlin and Turin.

L.M.S. Train Collision

IN a serious collision between a Crewe to Leeds express and a Crewe to Manchester train, which occurred at Holmes Chapel Station, near Sandbach, Cheshire, early last Sunday morning, nine persons were killed and about forty people injured, some twenty of them being detained in hospital. The express, which was a mail train, was standing almost stationary when the other train ran into the back of it, smashing up two coaches, in which most of the casualties took place. The engine of the oncoming train was forced on its side, and the track was torn up for about 50 yards, two of the coaches of the oncoming train being partly derailed. The driver and fireman on the engine were able to escape by jumping on to the embankment the moment before the collision occurred. Rescue work was immediately aided by members of the Home Guard, ambulances, and nurses, along with other helpers from first-aid posts, and the actual work of getting the dead and injured persons out from the wreckage was assisted by a searchlight installed in a field adjoining the track. An official statement which has since been issued by the London Midland and Scottish Railway Company states that the cause of the accident is under investigation. The work of clearing the blocked lines proceeded during the day, and to meet the traffic requirements alternative railway services and omnibus services were arranged.

Welfare Work Outside the Factory

THE Minister of Labour and National Service has just presented to Parliament a review of welfare work outside the factory in the period June, 1940, to August, 1941. It will be recalled that in June, 1940, the Minister established a Factory Welfare Department, comprising the factory inspectorate and the Welfare Department, which was transferred from the Home Office for the duration of the war. An Advisory Board was formed, of which the Minister himself is the Chairman, and Mr. George Tomlinson, Additional Parliamentary Secretary, the Deputy Chairman. That Committee includes individuals representative of the interests of workers and employers, of voluntary organisations, and of health services, together with senior members of the Ministry's staff. On the advice of the Board, the Minister also appointed a Central Consultative Council of Voluntary Organisations under the chairmanship of Lady Cynthia Colville. A similar Committee was set up in Scotland. Welfare Advisory Panels, composed of local representatives of voluntary organisations and other interested persons, have been set up in thirty-five areas to advise Local Welfare Officers in the organisation of welfare organisations. In addition to the headquarters staff of the Welfare Department, the Minister has appointed a Regional Welfare Officer to the staff of the Regional Controller of the Ministry in each of the eleven regions (generally corresponding to the Civil Defence Regions) to develop and supervise outside welfare work throughout the region and to keep in touch with Regional Officers of other Government Departments. Eighty-two Local Welfare Officers have also been appointed, each usually covering the area of a Labour Supply Committee. The main duties of these officers, who work under the general guidance and direction of the Regional Welfare Officers, are to try to secure through the appropriate authorities that all workpeople, especially those who have been transferred from other areas to work of national importance, have satisfactory accommodation, and that there are satisfactory arrangements for them to get meals and other necessities and to travel to their work, and that there is suitable provision for their recreation. A separate Committee has been appointed by the Minister to deal with seamen's welfare in ports.

The Acoustic Mine

IN the course of his recent review of the war in the House of Commons, Mr. Winston Churchill, the Prime Minister, made reference to the anti-mining service. Almost every night, he said, thirty to forty enemy aeroplanes were casting destructive mines, with all their ingenious variations, in the most likely spots to catch our shipping. The attack was begun with the ordinary moored mine, but it had been continued with the magnetic mine and the acoustic mine. It was now being continued, said Mr. Churchill, with the acoustic mine as well as the magnetic mine in many dangerous combinations. The acoustic mine, like the magnetic mine, does not depend on actual contact with a ship in order to detonate it, and it can therefore be dropped from aircraft in the shallow waters of harbours and narrow channels. The mine contains an electrical relay, which is adjusted to fire the charge when the ship's propeller is near enough for the ship to be blown up. It is known that our minesweepers are now equipped to deal with both magnetic and acoustic mines or their combinations. This means an added complication to their equipment, but they are continuing to discharge their task of keeping our harbours and channels clear with complete efficiency. Mr. Churchill stated that 20,000 men and 1000 ships toiled ceaselessly to clear our ports and channels every morning. Thanks, he said, to the resources of British science and British organisation, the menace had been largely mastered. Reference was also made by the Prime Minister to the work of the salvage service, which, he said, had recovered since the beginning of the war in every circumstance of storm and difficulty, considerably upwards of 1,000,000 tons of shipping which would otherwise have been cast away.

Lend-Lease Materials and British Export Trade

IN the correspondence which has passed between Mr. Anthony Eden, the Foreign Minister, and Mr. John G. Winant, the United States Ambassador in London, the policy of His Majesty's Government in the United Kingdom in connection with materials which are received from America under the Lend-Lease Act is explained. That correspondence has just recently been published as a White Paper. The policy of the Government is summarised as follows:—No materials of a type the use of which is being restricted in the United States on the grounds of short supply, and of which we obtain supplies from the United States, either by payment or on lend-lease terms, will be used in exports with the exception of the following special cases:—Material which is needed overseas in connection with supplies essential to the war effort for ourselves and our Allies, and which cannot be obtained from the United States; small quantities of such materials needed as minor though essential components of exports which otherwise are composed of materials not in short supply in the United States; repair parts for British machinery and plant now in use, and machinery and plant needed to complete installations now under construction, so long as they have already been contracted for. Steps have been taken to prevent the export (except to Empire and Allied territories) of such goods which do not come within the exceptions referred to above. Materials similar to those being provided under lend-lease which are not in short supply in the United States will not be used for export in quantities greater than those which we ourselves produce or buy.

Historic Accidents and Disasters

No. VI

(*Continued from page 162, September 12th*)

H.M.S. "THUNDERER"—PART II

H.M.S. "THUNDERER" was an unfortunate ship if ever there was one. For over three years she lay at Portsmouth awaiting her contractor's trials primarily because following the disaster to the "Captain" suspicion fell upon all seagoing low-freeboard turret ships. Eventually, in August, 1876, as we recorded in our previous article, she was about to run over the measured mile when one of her boilers exploded with disastrous consequences to the mixed company of naval stokers and contractors' men in the stokehold at the time. The damage done was duly repaired, and the suspicion as to her seaworthiness having been allayed, she was accepted into the Navy and some time in 1878 proceeded to the Mediterranean. On the morning of January 2nd, 1879, she was carrying out firing practice with her main armament off Ismid when one of her guns exploded, killing all, except a single man, of those within the turret.

The ship's main armament was carried in two turrets. In the after turret there were two 35-ton wrought iron muzzle-loading guns. In the forward turret there were two 38-ton guns of a special pattern, having a bore of 12in., instead of the usual 12½in., in order that their ammunition might be interchangeable with that of the guns in the after turret. The forward guns were therefore thicker and stronger than a normal 38-ton gun. In addition, the reduced calibre resulted in their firing a projectile 82 lb. lighter than the normal 38-ton gun and with 45 lb. less propellent charge. It might have been supposed that these two guns were the strongest of their type in the Service. Nevertheless, it was one of them that exploded. The explosion was of "astounding violence" and ruptured the gun into many fragments, large and small.

To mount a muzzle-loading gun inside a turret in such a way that it could be sponged out and loaded without the crew exposing themselves presented a problem which the advent of the breech-loading gun automatically solved. The solution adopted in the case of the "Thunderer" is illustrated herewith. After being fired the gun was withdrawn hydraulically and depressed through an angle of about 10 deg. in order to bring its muzzle into alignment with a loading hole beneath the gun port. The charge and the shot were raised on a hydraulic lift B and rammed home by means of a hydraulic rammer C. These operations were carried out by a loading party stationed beneath the main deck, who were also responsible for sponging out the gun between shots. The hydraulic system employed to move the gun in and out was combined with a spring-loaded valve arrangement for checking the recoil.

On the day of the disaster the first part of the practice consisted of firing all four guns in a broadside at a target 400 yards away, the firing being done by electrical control. Thereafter the guns were to be fired separately under hand control. When the broadside was fired it was known by all concerned that one of the guns in the after turret had not gone off. The order was therefore given to reload the two guns in the forward turret and the one gun in the after turret which had been discharged. Four minutes or so after the broadside the second part of the programme was begun. One of the guns in the forward turret was the first to be discharged. The explosion occurred when the second gun in that turret was fired.

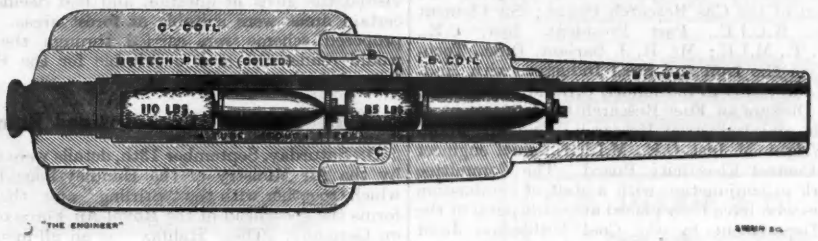
During the course of the inquiry conducted by a committee appointed to discover the cause of the disaster there was a material conflict of testimony as to what happened when the broadside was fired. All were agreed, as we have said, that one of the after turret guns had not gone off. Did one of the guns in the forward turret also misfire? Captain Chatfield, Sub-Lieutenant Fraser and John Cornish, A.B., testified that they saw three projectiles striking the water when the broadside was fired, thereby implying that both guns in the forward turret had gone off. Thomas Randall, one of the loaders, asserted that when the gun which exploded was presented for sponging after the broadside was fired smoke was issuing from its muzzle. The crew inside the turret must have been certain that the gun had gone off, for otherwise they would not have presented it for reloading. Indeed, the only survivor of the gun crew, W. Caswell, was positive in asserting that it had been discharged, while an armourer, James Hobbs, detailed to take charge of the electrical connections, testified that after the broadside he asked the men inside the turret whether both guns had gone off and had been told by them that they had done so.

This strong personal evidence that both guns in the forward turret had been discharged in the broadside was controverted by Signalman Trinham, J. Morgan, captain of the main-top, G. Snell, A.B., and John Wills, armourer. These four men told the committee that when the broadside was fired they saw only *two* shots striking the water. Further, Stoker Brakey, who was with the loading party, asserted, contrary to Randall's statement, that when the gun which exploded was presented for reloading he saw no smoke issuing from its muzzle.

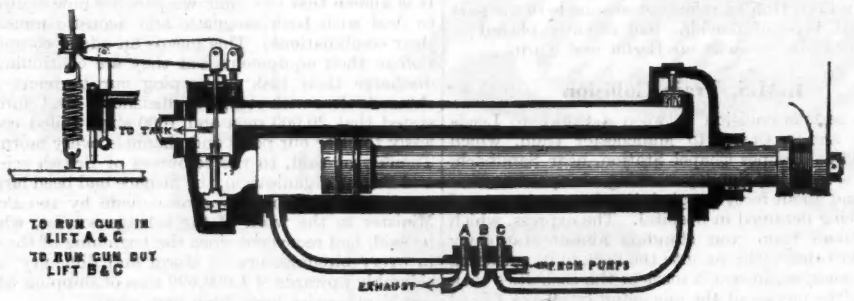
Turning from the personal to the material evidence, we have to note the fact that for the broadside the gun was loaded with a "battering charge" of 110 lb. and a Palliser shell, together occupying a length of 64in. For the individual firing in the second part of the programme a "full" charge of 85 lb. and a common shell was used. The length occupied by this second charge and shell was almost the same as before, namely, 64in. The length of the bore was about 16ft. 6in. It follows, therefore, that with either charge and shell the hydraulic rammer should have entered the bore to an extent of a little over 11ft. If, however, the broadside charge had not gone off and the individual charge had been rammed down against it, thereby double loading the gun, the rammer would have entered the bore of the gun to an extent of a little under 6ft. only. It would therefore have come to rest 5ft. or so short of its normal travel. Was it possible that the loading party could have failed to observe that the rammer had stopped short in its travel? Quite possible: the rammer was so highly polished that merely visual inspection was insufficient to enable anyone to say whether it was moving or stationary. But visual inspection was not necessary; a tell-tale was provided for the very purpose of indicating the exact travel of the rammer. What had it shown? Nothing; the cord operating it had been broken before the firing practice was begun and had not been repaired or replaced.

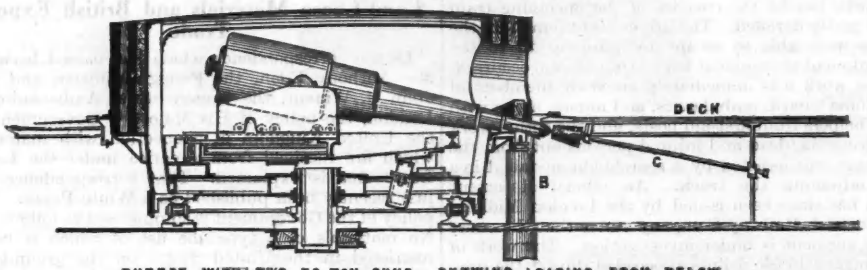
The material evidence, by an unhappy chance, therefore yielded no information one way or the other. The balance of the personal evidence was in favour of the belief that the broadside charge of the exploded gun had gone off. The evidence of those who said they saw three shells striking the water was cancelled by that of those who said they saw only two, while Randall's statement that he saw smoke issuing from the gun when it was presented for reloading was cancelled by Brakey's that he saw none. There remained the positive assertion of the sole survivor, Caswell, the implication to be drawn from the fact that those in the turret presented the gun for reloading after the broadside had been fired and Hobbs' testimony of receiving from the gun crew an actual verbal assurance that both guns had gone off.

Had the committee followed the balance of the personal evidence it would therefore have been compelled to reach the conclusion that the broadside charge had been disposed of before the gun was reloaded. It would then have had to face the task of explaining why an extra strong gun had burst violently when loaded with a subnormal charge and a subnormal shell. If it had succeeded in this task it would by inference have condemned as unsafe every 35-ton and 38-ton muzzle-loading gun then in use in the Navy. Nevertheless, had it felt compelled to reach this verdict it would have found support from Sir William Palliser and some other gunnery authorities who were prepared to explain in what manner the gun could have exploded with a single charge. It was pointed out that the gun was loaded with its muzzle depressed some 10 deg. below the horizontal, and that although the bore was rifled it was quite possible that after the rammer was withdrawn and before the gun was re-elevated the shell might have slipped down the bore and left a vacant space between its base and the forward end of the charge. Actual cases in which such slipping had occurred were on record, although no positive evidence seems to have been produced to prove that the existence of a vacant space between the charge and the shell would, as was implied, establish a danger of the gun bursting when the charge was fired. Sir William Palliser developed an alternative



SECTION OF THE 38-TON GUN WITH DOUBLE LOADING





TURRET WITH TWO 38 TON GUNS, SHEWING LOADING FROM BELOW & HYDRAULIC BUFFER

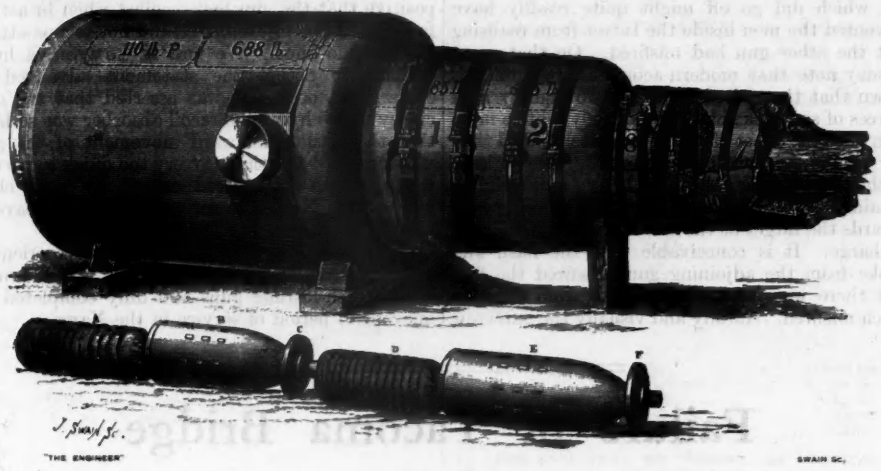
THE "THUNDERER" TURRET AND HYDRAULIC RECOIL ABSORBER

single-loading theory. He held the view—unsupported by any positive evidence—that the wad placed between the rammer and the nose of the shell had been partially withdrawn on the retreat of the rammer and that it remained as an obstruction in the bore, tilted the shell and caused it to jam.

The committee came unanimously to the conclusion that the gun had not gone off during the broadside practice and that accordingly it had subsequently been double loaded. It remained to be proved that double loading could result in the bursting of the gun. It was by no means self-evident that it would do so. The two charges, if there were two in the gun, would have amounted to 195 lb. Hundreds of rounds had, however, been fired by the Explosives Committee from a similar gun with charges of 160 lb., 180 lb. and 200 lb. without causing damage. Professor Osborne Reynolds, in a lecture before the Manchester Literary and Philosophical Society, suggested an explanation of this anomaly. The pressure generated by 200 lb. of explosive fired behind a single shell might be well within the capacity of the gun to withstand. In the "Thunderer's" gun, however, the charge would be in two portions, separated by a shell and preceded by a second shell. Reynolds supposed that the after, or 110-lb., cartridge could be fired without the flash passing the first shell and igniting the second, or 85-lb., cartridge. In those circumstances the first shot would be driven forward and would compress the second cartridge against the forward shot with a pressure equal to at least half the pressure of the gases generated behind the first shot, which would be between 10 and 20 tons per square inch. The powder of the second shot would be compressed, as by a violent blow, to a fraction of its former volume and the work of compression would raise its temperature far beyond its point of ignition. In that manner the entire mass of powder in the second cartridge would be simultaneously ignited in a highly compressed and heated state. The force of such an explosion would, he said, be practically unlimited and, he pointed out, would be developed at the very point at which the gun actually burst.

It may perhaps be thought to-day that Reynolds' theory depends too much on the inertia of the second shot, on the compression and heating of the second cartridge and on the supposition that the first shot was sufficient to prevent the flash of the first cartridge from passing to the second. The theory, it will be noticed, anticipated the essential feature in the cycle of the, as yet, unborn compression-ignition engine—with gunpowder as the "working fluid." It is an interesting theory, but a simpler, less assumptive, one will equally well serve to explain in what manner double loading could burst the gun. According to data submitted to the Court of Inquiry by Captain (Sir) Andrew Noble, of Elswick, a charge of 85 lb. fired in its normal position in the breach of a 12in. gun would produce an initial pressure of a little over 25 tons per square inch. As the shot moved along the bore the pressure would fall rapidly, becoming a little over 2 tons per square inch when the base of the shot reached the muzzle. The gun was constructed to withstand the falling pressure, its strength decreasing from the breech towards the muzzle. If the gun were double loaded the 85-lb. charge would lie at a position in the bore at which, according to Captain Noble, the strength was sufficient to withstand a pressure of 17 tons. If, therefore, the 85-lb. cartridge were fired when it was in this position its own initial pressure was by itself more than the gun at the point was designed to withstand. In addition, the pressure produced by the 85-lb. charge would be greatly increased by the addition of the pressure produced by the 110-lb. charge occupying its correct position in the breech. In this way, without making any of the assumptions involved in Reynolds' theory, we can readily understand how double loading the gun would result in the generation, at a particular portion of the bore, of a pressure greatly in excess of the designed strength of the gun at the point. It was just at that point that the gun burst.

The issue at stake was clearly much too important to permit any doubt to be tolerated concerning the cause of the disaster. It was felt necessary to justify the Court's verdict that the gun had been double loaded and that the double loading would account for its bursting. It was equally necessary to show that the gun could not have burst in the manner suggested by the exponents of the single-loading theory and in particular that the existence of a vacant space between the cartridge and the shot would not have proved fatal. It was decided to test the surviving 38-ton gun to destruction. For that purpose it and the fragments of the burst gun were brought home and sent to Woolwich Arsenal. To provide a standard of comparison the fragments of the burst gun were assembled in their relative positions, certain unrecovered portions, notably the whole of the muzzle end, being necessarily omitted.

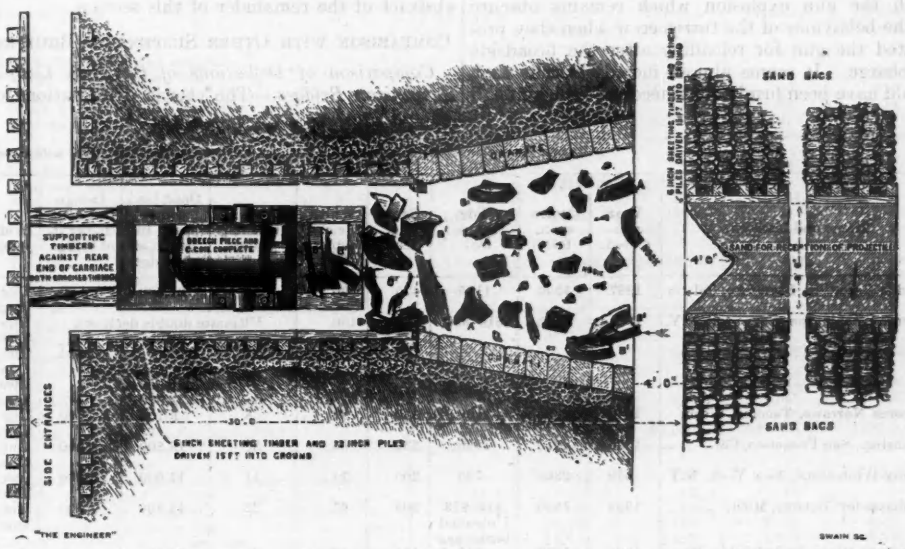


THE RECOVERED FRAGMENTS OF THE EXPLODED GUN REASSEMBLED

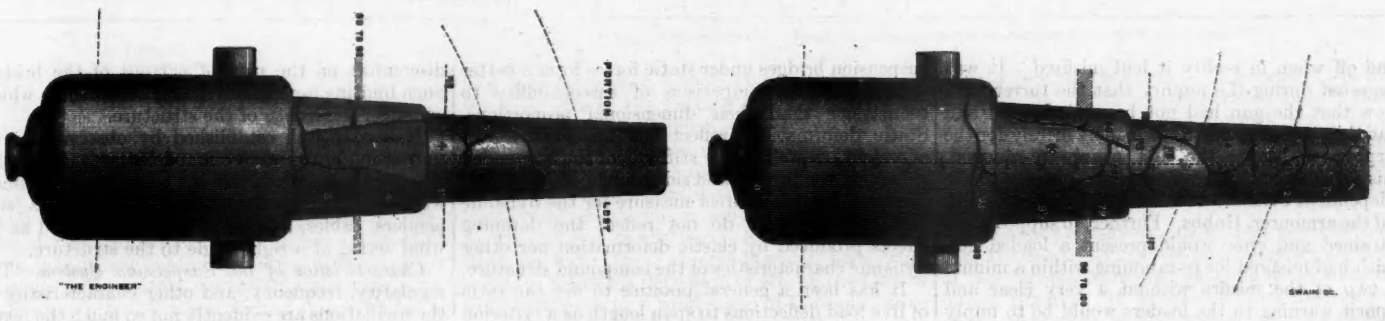
The trials were begun on December 9th, 1879. The gun was first fired single loaded with an air space between the cartridge and the base of the shell varying in successive trials from zero up to as much as 10ft. Both common shells weighing about 580 lb. and Palliser shells weighing about 700 lb. were used, the respective propellent charges being 85 lb. and 110 lb. Provision was made for measuring the pressure developed within the bore during each discharge. Not only was the gun completely uninjured by the existence of an air space between the cartridge and the shell; the pressure developed fell consistently and rapidly as the air space was increased. With common shells, for example, the pressure amounted to 20·2 tons with zero air space. With 1ft. of air space it fell to 12·4 tons and by the time the air space had reached 10ft. the pressure had fallen to 0·5 ton. These tests conclusively proved that the existence of an air space between the cartridge and the shell was a source not of danger, but of safety.

Next experiments were carried out to test the merits of Sir William Palliser's theory that the gun had burst by the wedging of the shell against the wad. The wad, a thick disc of millboard, was placed in the bore 5ft. in front of the shot and the gun was loaded with a common shell and 85 lb. of powder. Two trials were carried out, one with the wad tilted in the bore at an angle of 45 deg. and the other with the wad placed fair in the bore. In both cases the wad, when the gun was fired, was cut into fragments without the least injury being done to the gun.

It remained to test the gun when double loaded. The test was carried out on February 3rd, 1880, before a large number of spectators. The cell in



THE BURSTING CELL AT WOOLWICH



THE GUN BURSTS COMPARED

which the gun was mounted was greatly strengthened for this test. Beyond the muzzle of the gun the cell walls were lined with granite blocks, while the rear portion was lined with timber sheathing supported on 12in. wooden piles. Thick concrete was applied externally and finally a backing of earth. In front of the cell and separated from it by a space of 4ft. was a sand gallery 8ft. 6in. square in section and 45ft. long, on and around which were piled 15,000 sandbags.

The gun was loaded with a charge of 110 lb., a Palliser shell, with gas check, weighing 688 lb., a millboard wad, a charge of 85 lb., a common shell, with gas check, weighing 575 lb., and finally a millboard wad. In this manner the conditions believed to have existed at the time of the disaster were reproduced as nearly as possible, the only important difference beng that the gun was loaded with a hand rammer instead of by means of a hydraulic rammer. When the gun was fired the sound heard was low and rather dull and did not suggest that anything unusual had happened. When the butt was entered, however, it was found that the gun had burst explosively and had broken up into many fragments, the point of rupture being almost exactly at the same place as that at which the principal fracture occurred in the gun which burst on the "Thunderer," namely, adjoining the zone occupied by the 85-lb. charge. An attempt was made in some quarters to dispute the clear evidence furnished by the test. Emphasis was laid on certain minor differences in the two exploded guns and there was much discussion concerning their significance. In time, however, everyone became agreed that the Woolwich experiments provided complete justification for the view that the "Thunderer's" gun had burst because it had been double loaded.

The two disasters, of which the "Thunderer" was a victim, present, it will be noted, a curious contrast. That involving one of her boilers was full of mystery and was never satisfactorily explained. The gun disaster, equally mysterious at first, yielded its secret and in due course was explained in a completely satisfactory and convincing manner. Almost the only point connected with the gun explosion which remains obscure is the behaviour of the turret crew when they presented the gun for reloading after the broadside discharge. It seems almost incredible that they could have been firmly convinced that the gun had that they were foolhardy in the extreme and utterly lacking in all sense of responsibility towards their ship and their shipmates.

We are compelled to believe that the gun crew thought the gun had gone off beyond a shadow of doubt. How did they come to make such a mistake? Did they rely on the evidence of their ears? If they did so, they might well have been misled. The guns during the broadside practice were fired electrically and therefore presumably simultaneously. The noise of the discharge of the gun which did go off might quite readily have prevented the men inside the turret from realising that the other gun had misfired. On that point we may note that modern acoustical research has shown that the united effect of two equally loud sources of sound is not twice but only a little more than once the effect of either separately. Did they rely on the evidence of their eyes? One at least of the turret crew, the gun layer, must almost certainly have been looking through the gun port towards the target at the moment of the broadside discharge. It is conceivable that the flash and smoke from the adjoining gun obscured the fact that there was no flash or smoke from the gun which misfired. Aurally and visually the gun crew might therefore have been misled into thinking that the gun had gone off. They had, however, a third means of judging whether it had been discharged or not, a seemingly infallible means and one too which was open to the observation of probably the majority of their number—the existence or absence of recoil. Lacking direct means of examining the bore of the gun, they had in the recoil the only sure and positive means of determining whether the gun had fired or misfired. How did it come about that they were apparently positive that the gun had recoiled when in actual fact it had not? This point did not escape attention at the time. We find it, however, a little difficult to accept the statement advanced in explanation of it. It was asserted that the efficiency of the hydraulic recoil absorber was so high that the actual backward movement of the gun was too small and the recovery too quick to permit the recoil to be noticed except by very close inspection. Not quite satisfied, we must leave it at that.

The "Thunderer," so far as we know, experienced no further major misfortunes. She was re-armed with breech-loading guns and duly completed an uneventful period of service in the Navy.

Failure of Tacoma Bridge

No. IV

(*Continued from page 164, September 12th*)

THE next section of the report consists of a comparison of the Tacoma bridge with other bridges of comparable size. Much of the early part of this section is in effect summarised by the accompanying Table I reprinted below, attention being devoted to the sag, span-to-width and span-to-stiffness girder ratios. Attention is also directed to the importance of weight as a stiffening factor. Mention is made of installations at other bridges of devices intended to check oscillations. What follows is an abstract of the remainder of this section.

Comparison with Other Suspension Bridges

Comparison of Deflections of the Five Longest Suspension Bridges.—The elastic deformations of suspension bridges under static forces form a better approach to a comparison of susceptibility to oscillations than their dimensional proportions. Static deformations reflect the important effect of weight, as well as the stiffness of the suspended structure, the towers, and side spans. They do not, however, furnish a direct measure for the dynamic rigidity since they do not reflect the damping effects produced by elastic deformation nor other dynamic characteristics of the compound structure.

It has been a general practice to use the ratio of live load deflections to span length as a criterion and limitation for the rigidity of bridges of ordinary types. Table II lists for the five longest suspension bridges the principal properties which affect the static deformations, and also the maximum deflections, vertically, laterally, and in torsion, under the design loads. This criterion evidently does not apply to the rigidity of long-span suspension bridges under wind action.

It is now evident that limitation of flexibility in long-span highway suspension bridges is not primarily a question of safety of the structure under maximum loads, nor of sufficient rigidity under impact effects of moving loads, but one of keeping oscillations produced by wind within such small limits so as not to produce the feeling of danger or discomfort on the part of patrons of the bridge. Such limiting oscillations are far below those which endanger the safety of the structure.

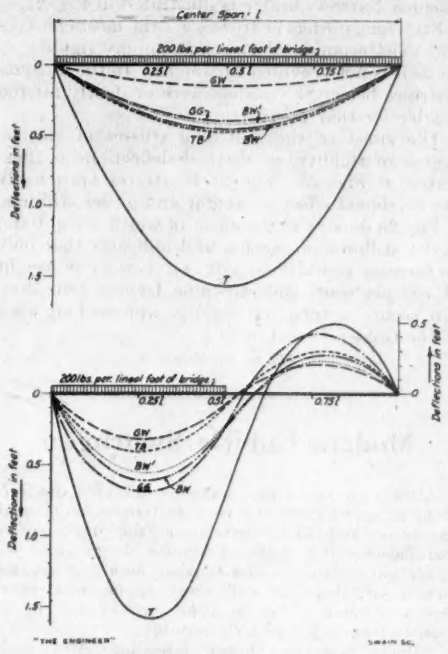
It is now well established by observations on suspension bridges and on models that such oscillations may be produced by comparatively small wind forces acting longitudinally on towers, suspenders, cables, and floor structure, as well as by wind acting at a right angle to the structure.

Characteristics of the Suspension System.—The regularity, frequency, and other characteristics of the oscillations are evidently not so much the result

TABLE I.—*Dimensions of Suspension Bridges Built Since the Year 1900 with Spans of 1200ft. or Over*

Name and location.	Year completed.	Centre span, feet.	Side spans, feet.	Cable sag, feet.	Width c.c. cables, feet.	Depth of stiffening girder, feet.	Dead load centre span, lb. per ft. of bridge.	Design live load, lb. per ft. of bridge.	Width of roadway and sidewalks.	No. of elec. rly. tracks.	Ratio cable sag to span.	Ratio width c.c. cables to span.	Ratio depth of stiff'g girder to span.	No. and dia. of cables.
Golden Gate, San Francisco, Cal. ...	1937	4200	1125	475	90	25	21,600	4,000	One 60ft. rdy. Two 10ft. s.w.	None	1/9	1/47	1/168	Two 36½in.
George Washington, New York, N.Y.	1931	3500	610–650	325	106	Ultimate double deck condition			One 30ft. 6in. rdy. Two 28ft. 9in. rdys. Two 10ft. s.w.	4	1/11	1/33	Double deck 1/120	Four 36in.
						29	39,000	8,000						
						Present single deck condition			One 30ft. 6in. rdy. Two 28ft. 9in. rdys. Two 10ft. s.w.	None			Single deck —	
						—	31,500	—						
Tacoma Narrows, Tacoma, Wash....	1940	2800	1100	232	39	8	5,700	1,000	One 26ft. rdy. Two 5ft. s.w.	None	1/12	1/72	1/350	Two 17¼in.
Transbay, San Francisco, Cal. ...	1936	2310	1160	231	66	30	18,800	8,000	One 58ft. rdy. One 31ft. rdy.	2	1/10	1/35	1/77	Two 28⅝in.
Bronx-Whitestone, New York, N.Y.	1939	2300	735	200	74	11	11,000	3,000	Two 27ft. 6in. rdys. Two 5ft. s.w.	None	1/11·5	1/31	1/209	Two 22in.
Ambassador, Detroit, Mich.	1929	1850	817–973 Unloaded backstays	209	67	22	12,400	3,300	One 47ft. rdy. One 8ft. s.w.	None	1/8·9	1/27·6	1/84	Two 19½in.
Delaware River, Philadelphia, Pa....	1926	1750	716·7	197	89	28	26,000	6,000	One 57ft. rdy. Two 10ft. s.w.	4	1/8·9	1/19·7	1/62·5	Two 30in.
Bear Mountain, West Point, N.Y....	1924	1632	Unloaded backstays	200	61·3	30	11,540	3,160	One 38ft. rdy. Two 5ft. s.w.	None	1/8·2	1/26·6	1/54	Two 18⅛in.
Williamsburg, New York, N.Y. ...	1903	1600	596 Unloaded backstays	178	67	40	17,200	5,700	Two 20ft. rdys. Two 17ft. s.w.	6	1/9	1/23·7	1/40	Four 18⅛in.
Lion's Gate, Vancouver, B.C.... ...	1938	1550	615	150	40	15	4,600	1,230	One 29ft. rdy. Two 5ft. s.w.	None	1/10·3	1/38·8	1/104	Two 13½in.
Mid Hudson, Poughkeepsie, N.Y....	1930	1500	750	150	42	20	8,800	3,000	One 30ft. rdy. Two 4ft. s.w.	None	1/10	1/35	1/75	Two 16⅛in.
Manhattan, New York, N.Y.	1909	1470	725	148·5	96	24	23,280	8,000	One 35ft. rdy. Two 13ft. s.w.	8	1/9·9	1/15·3	1/61	Four 21½in.
Triborough, New York, N.Y.	1936	1380	705	138	98	20	20,000	4,000	Two 43ft. 6in. rdys. Two 5ft. 6in. s.w.	None	1/10	1/14·1	1/68	Two 20⅝in.
St. John's, Portland, Ore.	1930	1207	430	121	52	18	—	—	One 40ft. rdy. Two 5ft. s.w.	None	1/10	1/23·2	1/67	Two 16⅛in.
Mount Hope, Providence, R.I. ...	1928	1200	504	120	34	18	5,300	1,500	One 27ft. rdy. One 2ft. 6in. s.w.	None	1/10	1/35	1/67	Two 11in.

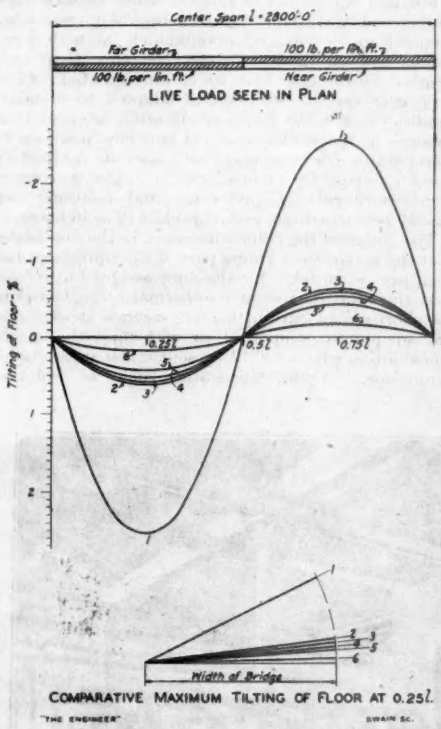
of intensity, frequency, direction, and distribution of the wind impulses, but lie largely in the behaviour of the suspension system when acted upon by dynamic forces. Freely suspended cables are very sensitive to displacements under forces acting in their vertical planes. Very small forces may create comparatively large displacements of the cable



T. Tacoma.
G.W. George Washington.
T.B. Transbay.
G.G. Golden Gate.
B.W. Bronx-Whitestone.
B.W.[1] Bronx-Whitestone with stays.

FIG. 22—COMPARATIVE VERTICAL DEFLECTIONS

catenary, and since little of the energy input by dynamic forces is absorbed by the elastic deformations, successive energy impulses may easily create large oscillations. Model tests show that, after cessation of dynamic impulses, the relatively flexible suspension systems continue to oscillate



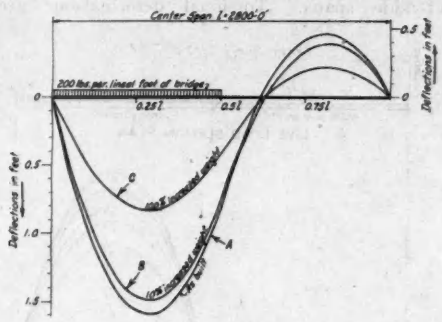
1. Tacoma.
2. Golden Gate.
3. Bronx-Whitestone.
4. Transbay.
5. Bronx-Whitestone with stays.
6. George Washington.

FIG. 23—COMPARATIVE TILTING OF FLOOR

for a long time before they come to rest. Comparatively small energy impulses applied at very irregular and infrequent intervals are sufficient to keep unstiffened cables oscillating indefinitely or to cause progressively increasing amplitudes.

The more flexible the stiffening system—that is, the nearer the compound system approaches the unstiffened cables—the more sensitive it is, and the longer it persists in the state of oscillation after energy impulses are removed. Moreover, the more flexible the system, the more easily it oscillates in increasing numbers of waves or nodes at higher frequencies. This is clearly illustrated by the relative behaviour of those bridges which have experienced oscillations and also by the models.

The comparative deflections as an indication of the susceptibility of different suspension bridges



Design of bridge.	Dead load, lb. per lin. ft.
A. As built	5,700
B. 10 per cent. increased weight	6,270
C. 100 per cent. increased weight	11,400

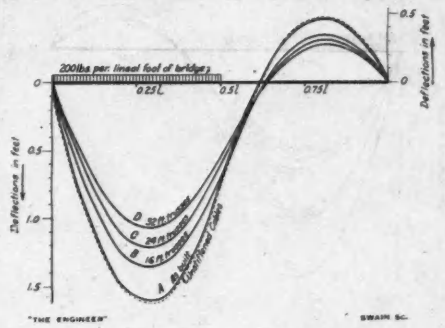
FIG. 24—EFFECT OF WEIGHT ON VERTICAL DEFLECTIONS

to dynamic motions have been calculated for the Tacoma Narrows bridge and the four other suspension bridges of comparable magnitude. These bridges show a wide variation in the elements which influence the deformations of the compound structure, vertically, laterally, and in torsion.

Fig. 22 illustrates graphically the comparative vertical deflections of these five bridges.

Lateral Deflections and their Relationship to Width.—The comparison of lateral rigidities of effect on people on the bridge, and they were well within the safe deflections for which the bridges are designed. The Tacoma Narrows bridge during its most violent vertical torsional motions under a wind velocity of 42 m.p.h. exhibited lateral movements to the extent of only a few feet. No lateral motions of more than a few inches have ever been observed on the George Washington bridge and on the Bronx-Whitestone bridge.

Table II gives the maximum lateral deflections on the five longest suspension bridges based upon the design wind pressures. Based upon the ratio



Design of bridge.	M. of I. for both girders, in.² ft.²	Dead load, lb. per lin. ft.
A. As built	2,567	5,700
B. 16ft. trusses	1,500	6,600
C. 24ft. trusses	36,000	6,840
D. 32ft. trusses	63,000	7,050

FIG. 25—EFFECT OF RIGIDITY OF STIFFENING GIRDERS

of deflection to span, the Tacoma Narrows bridge is about 40 per cent. more flexible than the Golden Gate and Transbay bridges, 80 per cent. more than the Whitestone bridge, and 125 per cent. more than the George Washington bridge.

In long-span suspension bridges with a relatively

TABLE II.—*Elastic Properties and Principal Deflections from Design Loads of Five Longest Suspension Bridges*

Name of bridge	Golden Gate	George Washington	Tacoma Narrows	Transbay	Bronx-Whitestone
General dimensions and weight—					
Length of centre span, feet	4,200	3,500	2,800	2,310	2,300
Length of side spans, feet	1,125	650	1,100	1,160	735
Width between cables, feet	90	106	39	66	74
Average weight of centre span, lb. per lineal foot	21,035	31,590*	5,700	18,740	11,000
Properties of cables—					
Number of cables	2	4	2	2	2
Cable sag, feet	475	319·2*	232	231	200
Diameter, inches	36¾	36	17¼	20¾	22
Net section, all cables, square inches	1,664	3,195	383	1,050	594
Properties of stiffening girders—					
Number of girders and type	2 trusses	2 chords	2 pl. girders	2 trusses	2 pl. girders
Depth (c.c. chords for trusses), feet	25	—	8	—	11
Moment of inertia, all girders, in.² ft.²	88,000	168	2,567	156,000	5,860
Properties of lateral system—					
Horizontal wind force acting on floor and vehicles, lb. per lineal foot	1,130	1,200	560	1,400	800
Horizontal wind force acting on cables, lb. per lineal foot	200	300	60	145	120
Total wind force on floor and cables, lb. per lineal foot	1,330	1,500	620	1,545	920
Width of wind truss, feet	90	106	39	66	74
Moment of inertia, wind truss, in.² ft.²	1,236,000	481,000*	95,000	743,000	410,000
Properties of towers—					
Height of towers (top of pier to centre of cable)	702	582	425	462·41	353
Width at top (parallel to bridge axis), feet	24·6	37·5	13	15	12
Width of bottom (parallel to bridge axis), feet	52·6	56	19	32	18
Area at top—both tower legs	7,340	5,978	1,524	3,712	3,300
Area at bottom—both tower legs	14,384	14,624	2,287	8,000	4,200
Average moment of inertia, both tower legs, in.² ft.²	1,500,000	3,130,000	40,500	290,000	60,000
Vertical deflections from live load at normal temperature					
Live load, lb. per lineal foot bridge	4,000	4,000	1,500	6,000	3,000
Down at quarter point of centre span, load half centre span, tower to centre	12·41	5·88	10·95	10·70	8·41
Up at three-quarter point of centre span, same loading	6·72	3·54	2·74	7·50	3·30
Down at centre load centre span	7·34	2·92	10·50	11·85	6·50
Up at centre load side spans	2·34	0·48	5·93	8·18	2·35
Maximum change in gradient	2·6	1·2	3·6	3·3	2·8
Maximum gradient	5·7	3·4	6·2	6·3	6·8
Tilting from live load at quarter point of centre span	10·88	4·44	17·54	14·27	7·88
Lateral deflection of truss from design wind at centre of centre span	21·5	10·7	20·03	11·42	8·93
Maximum longitudinal deflection of tower top from live load	1·36	0·34	1·98	2·53	0·83

* Single-deck condition. Final condition :—39,500 lb. per lineal foot of bridge ; sag, 325ft.

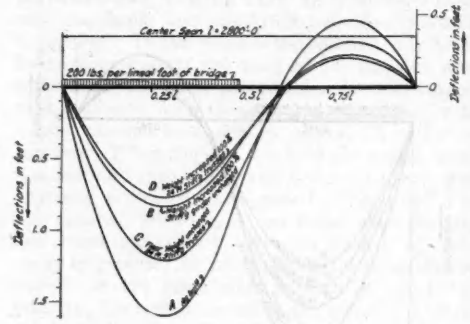
long-span suspension bridges and their bearing on the behaviour of the Tacoma Narrows bridge presents a different and much simpler problem than the vertical rigidity. None of the modern suspension bridges listed in Table I, inclusive of the Tacoma Narrows bridge, has shown objectionable lateral movements under wind action comparable to the vertical oscillations. Such lateral deflections as have been observed under high wind velocity, notably a deflection of 8ft. on the Golden Gate bridge during a wind storm of 75 m.p.h., have been slow and sluggish without any objectionable narrow flexible wind truss, a large part of the wind force acting on the suspended structure is transmitted to the cables, and through them to the towers. It follows that the lateral stability and deflection of the suspended structure is largely independent of the rigidity and width of the wind truss.

The above considerations lead to the conclusion that the relatively narrow and flexible wind truss of the Tacoma Narrows bridge supplied sufficient lateral rigidity. It is evident from observations of the behaviour of the bridge that this rigidity

was sufficient to prevent dangerous or even objectionable lateral oscillations.

Comparative Torsional Deformations.—A comparison of torsional deflections of different suspension bridges as an indication of their susceptibility to torsion by wind action may be based either on an assumed torsional moment or on assumed small vertical forces which create torsion.

Either of these two force conditions furnish a qualitative comparison of torsional rigidities. The second conditions, assuming the vertical forces



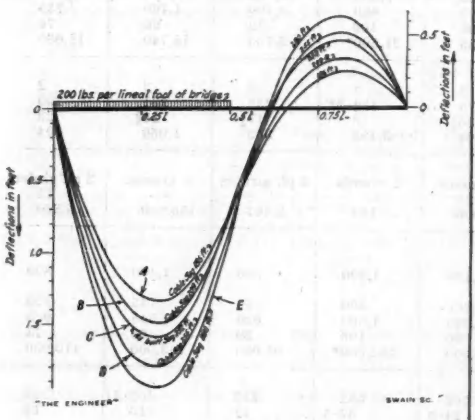
Design of bridge.	M. of I. for both girders, in.² ft.²	Dead load, lb. per lin. ft.
A. As built	2,567	5,700
B. Weight increased 100 per cent. Stiffening girder unchanged	2,567	11,400
C. Floor weight unchanged 24ft. stiffening trusses ...	36,000	6,840
D. Weight increased 100 per cent. 24ft. stiffening trusses ...	36,000	11,400

FIG. 26—COMBINED EFFECT OF WEIGHT AND RIGIDITY OF STIFFENING GIRDERS

acting in the planes of the cables, would appear to furnish a more rational quantitative comparison.

In Fig. 23 the comparative torsion or tilting of the floor is based on a load of 100 lb. per foot along the near cable from one tower to the centre and the same load along the far cable from the centre to the other tower.

The ratios of torsional flexibility of the Tacoma Narrows bridge to that of the other four large



Design of bridge.	Area both cables, in.²	Dead load, lb. per lin. ft.
A. Cable sag. 186ft.	491·86	6,120
B. Cable sag. 209ft.	432·24	5,870
C. As built. Sag 232ft.	380·64	5,700
D. Cable sag. 255ft.	343·96	5,540
E. Cable sag. 280ft.	311·86	5,420

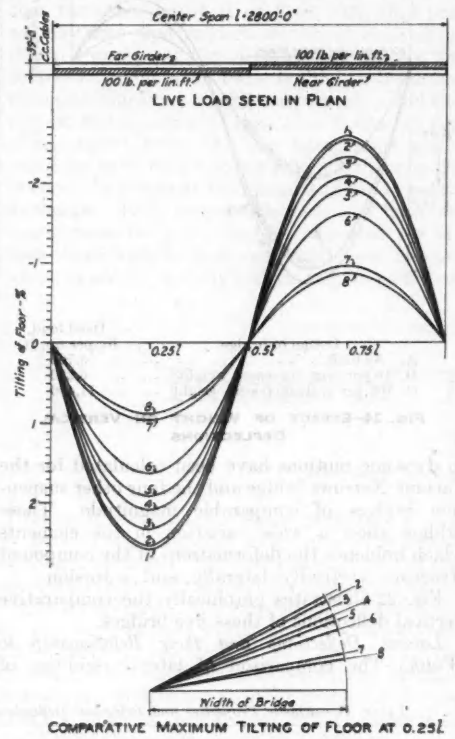
FIG. 27—EFFECT OF CABLE SAG

suspension bridges, on the basis of the above two force conditions, is as follows :—

	Based on torsional moment	Based on vertical forces (Fig. 23)
Golden Gate bridge	12·4 to 1 ...	4·2 to 1
Bronx-Whitestone bridge, without stays	9·4 to 1 ...	4·4 to 1
Ditto, with stays	10·7 to 1 ...	5·9 to 1
San Francisco Transbay bridge	11·4 to 1 ...	4·9 to 1
George Washington bridge ...	38·0 to 1 ...	14·1 to 1

This comparison shows that the Tacoma Narrows bridge was far more susceptible to torsion than any of the other bridges. This comparatively great torsional flexibility is due to a combination of exceptionally great vertical flexibility and unusually narrow width, and not to lack of torsional resistance of the floor structure, nor to the narrowness of the bridge alone.

Effect of Various Elements of Structure on Vertical and Torsional Deformations of Tacoma Narrows Bridge.—In order to be able to visualise more clearly the reasons for the unusually large vertical and torsional deformations of the Tacoma Narrows bridge, and to determine how and to what extent they may be controlled to obtain greater rigidity, it is essential to analyse the extent to which the various elements of the structure contribute to the deformations of the compound system. The principal elements which influence vertical deflections are weight, cable sag, stiffening girders, towers and side spans. Torsional deformations are



COMPARATIVE MAXIMUM TILTING OF FLOOR AT 0.25l

Design of bridge.	Width of bridge. ft.
1. Unstiffened	39
2. As built	39
3. 10 per cent. weight increase	39
4. 16ft. trusses	39
5. 24ft. trusses	39
6. 32ft. trusses	39
7. 100 per cent. weight increase	53
8. 100 per cent. weight increase 24ft. trusses	53

FIG. 28—EFFECT OF WIDTH, WEIGHT, AND GIRDER STIFFNESS

influenced by the vertical deflections, hence by all the above-mentioned elements, and by the width between cables.

To bring its comparative vertical rigidity within the range of the Golden Gate and Whitestone bridges would require that the Tacoma Narrows bridge be made two and a-half times heavier than it was, other proportions remaining the same. This would manifestly be wasteful. The effect of weight is shown graphically in Fig. 24.

A decrease of 10 per cent. or from 232ft. to 209ft. (ratio to span 1 : 13·4) in the cable sag of the Tacoma Narrows bridge decreases the maximum deflection at the quarter point from 1·59 to 1·49 or by only 6·3 per cent. This would evidently go only a short way towards supplying the deficiency in rigidity in the Tacoma Narrows bridge and indicates that the effect of the relatively flat cable sag of one-twelfth was greatly over-estimated.

The effect of sag on vertical deflections of the Tacoma Narrows bridge is illustrated in Fig. 27.

Stiffening girders or trusses are the most effective and most economical means to supply rigidity as far as it is not provided by weight. In the Tacoma Narrows bridge the girders were evidently far too flexible for that purpose.

The effect of the stiffening trusses of various degree of rigidity on vertical deflections is illustrated in Fig. 25. Fig. 26 illustrates graphically the combined effect of weight and girder stiffness.

Fig. 28 illustrates the effect of width, weight and girder stiffness on torsion and indicates that only an increase in width to 53ft., an increase in weight of 100 per cent. and stiffening trusses 29ft. deep can secure a torsional rigidity approaching that of the Golden Gate bridge.

(To be continued)

Modern Cubicle Switchgear

ALTHOUGH there has been considerable development in recent years of special switchgear units, such as compound-filled switchgear for high-tension installations and units of similar design with air insulation, both for low-tension and high-tension switchgear, there are still many applications where the air-insulated cubicle type switchboard in its modern form is particularly suitable.

Cubicle type switchgear falls into two main classes :—(1) Consisting of a self-contained steel structure enclosed with steel plates fitted with a door for access to the interior ; (2) draw-out truck type. Either form may be operated at the cubicle itself or remotely, mechanically or electrically. The advantage of the cubicle type switchgear is its flexibility of lay-out, ease of access and accessibility for maintenance purposes. When properly designed and manufactured it can, it is claimed, be made just as reliable as any other form of switchgear ; and, indeed, in some respects more reliable, as proper clearances in air can be maintained and adequate insulation of the porcelain or other insulating material provided without the complications and limitations attendant on totally enclosed unit type gear.

For mill and works switchgear where maintenance staff is readily available the advantage of not requiring frequent inspection and maintenance as with compound and oil-filled switchgear is more than outweighed by the ease with which air insulated cubicle type gear can be altered and adapted to changed conditions of works loading. It often happens that changes in the works products and new methods of manufacture or machine tool lay-out completely upset previous feeder loadings. Changes in current transformer ratings, protection and metering can readily be carried out with this class of switchgear.

The design of the cubicle assumes, in the first place, that the apparatus forming part of the equipment has been proved suitable for the duty assigned to it, and that the connections have a thermal rating equal to the short-circuit current for five seconds at least and are adequately supported to withstand the mechanical forces which will be present under short-circuit conditions. Again, apparatus such as isolating

FIG. 1—INDUSTRIAL DISTRIBUTION SWITCHBOARD

switches must have adequate thermal capacity and the design must be such that the supporting insulators are strong enough to withstand short-circuit forces and that under no circumstances can these short-circuit forces cause an opening of the isolating switches. Calculations must be made for the bus-bar systems and connections to ensure that resonance cannot occur and in the case of heavy current cubicles and, at the same time, to provide interlocks of the key exchange type which will ensure that the short-circuit energy on any one section cannot be exceeded. Cubicles of this type are often arranged in conjunction with ironclad oil circuit breaker units for use with capacities up to 1200 amperes dealing with outgoing circuits. An example of a cubicle of this kind under construction is shown in Fig. 1. Where a cartridges. The rating of the fuse so used should be equivalent to the maximum short-circuit rating of the switchboard.

The position, therefore, can be summed up by saying that when selecting switchgear for a particular installation due consideration should be given to the various types available and sufficient space should be allowed in the lay-out. Provided proper selection has been made of the switchgear unit and that it has been proved in all respects to be suitable for its duty, it should offer maximum facilities for overhaul, allow of inspection being carried out in the shortest possible time and permit maintenance to be attended to which might not otherwise be done if the time factor were such that it would mean shutting down the switchboard for a period when production is required.

FIG. 2—IRONCLAD SWITCHGEAR. 3300 V. 150,000 KVA

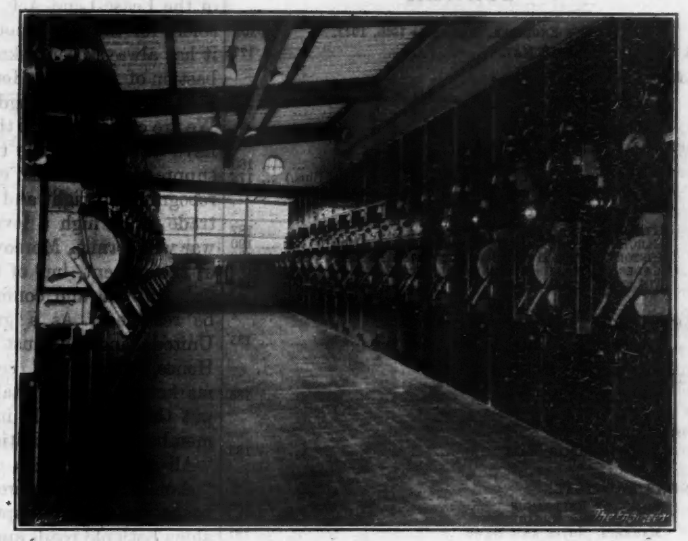


FIG. 3—MAIN FEEDER SWITCH UNITS. 3300 V. 150,000 KVA

that there is sufficient ventilating means provided to ensure dissipation of the heat generated from all causes within the cubicle. Vents from oil circuit breakers must be positioned so that any discharge is directed away from live conductors and preferably outside the enclosure containing such connections.

In the modern form of cubicle the oil circuit breaker is usually mounted on its own self-supporting frame, which can be placed inside the cubicle and independently secured to the floor instead of bolting it directly into the frame of the cubicle, as in former practice. This procedure has many advantages, in that the oil switch is securely mounted and its movement is prevented under the worst short-circuit conditions. It permits also the use of a tank lowering device to facilitate an examination of the contacts and the entire oil switch and supporting frame can be withdrawn from the cubicle should any major overhaul work become necessary. For this reason, in some instances, small rollers are often fixed to the oil switch carriage. Cable jointing and access to the feeder isolators, if provided, is facilitated by carrying out such work with the oil circuit breaker and frame removed from the cubicle. Cubicles with front access only can be completely dismantled and rebuilt with the bus-bars still alive by this comparatively simple removal of the oil circuit breaker, which is first isolated, leaving the compartment in which the circuit breaker is mounted dead.

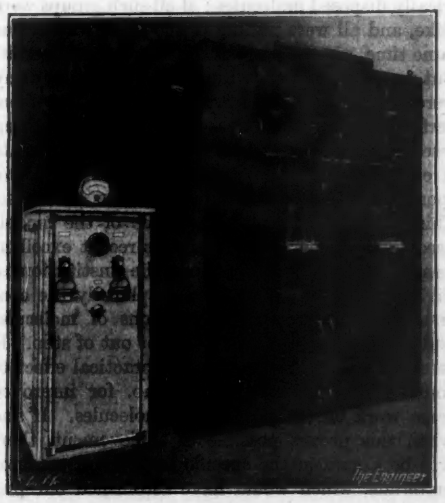


FIG. 4—CUBICLE SWITCHGEAR. 5000 A. 400 V.

On low-tension cubicles forming part of heavy current distribution boards, where there is more than one incoming feeder, it is often desirable, in order to limit the short-circuit current on any part of the board, to arrange them in sections so that only one incoming feeder may be connected to any section at a time, but with provision to enable one section to be made alive from the other when desirable. In such cases it is easy with cubicle gear to arrange by-passing isolators in the main incoming cubicles which will permit a feed through from one section to another duplicate bus-bar system is desired it can be equally well accommodated in the cubicle type of switchgear.

Many well-known electrical undertakings use cubicles specially designed to suit their requirements for the control of high-tension systems. An added advantage in such cases is that the cubicles can be supplied by several manufacturers, all conforming to the same exterior dimensions and lay-out to preserve standardisation. The cubicle type switchgear shown in Fig. 2 was installed in a new board mill, where a high-tension generating station switchboard was provided for the control of turbo-alternators and outgoing feeders. Fig. 3 shows a typical machine room switchboard, while Fig. 4 illustrates a 5000-ampere, 400-volt cubicle fitted with two 2500-ampere oil switches in parallel and solenoid operated. The small cubicle on the left contains a duplicate copper oxide rectifier equipment for the standby supply of D.C. energy to the solenoids from the A.C. supply. Where greater facilities for immediate inspection are required and the room is available the truck type cubicle is still being used to a large extent. A typical example of such equipment is shown in Fig. 5. Oil switches having a rupturing capacity of 350 mVA are incorporated in this equipment and duplicate bus-bars are fitted.

Short-circuit tests have been carried out recently at the Crompton Parkinson switchgear testing station to determine the ability of truck units as a whole to withstand the thermal and mechanical stresses. For this purpose two complete units with their bus-bar system were mounted in the test cell and subjected to a current equal to the short-circuit rating for a period of five seconds. Tests of this nature readily show up any defect in design, prove the strength of insulating supports and remove any doubt as to the ability of the units to operate satisfactorily under its short-circuit rated conditions. It is worth mentioning that whilst compliance with British Standards Specification as regards short-circuit capacity is usually insisted upon for oil circuit breaker performance, isolators, connections, current transformers and bus-bar systems must also have similar short-circuit ratings, otherwise the advantages of a proved circuit breaker are lost. Under the heading "Connections" must be placed small or secondary wiring connections taken to instruments, meters or relays. In the case of low-tension switchgear, if such connections are taken directly from a bus-bar system—where the short-circuit energy may be 25,000 kVA—any fault on the small wiring system may result in the destruction of the whole of the small wiring and possibly a fire. This consequence can be avoided by taking all secondary wiring connections first through a copper strip of adequate dimensions to a high-rupturing fuse cartridge and thence by normal switchboard wiring to the instruments, meters or relays. Such fuses should be placed in a position where access is possible after proper precautions have been taken to avoid possible electric shock. The fuses will, by virtue of their rapid action, disconnect the faulty small wiring before damage can result if a fault develops in the small wiring. These fuses should be used for short-circuit protection only, ordinary instrument circuit potential fuses being used in addition. The first-named fuses should have a fusing value in excess of the instrument potential fuse to ensure that the latter operates for all normal overcurrents without blowing the high-rupturing capacity

FIG. 5—TRUCK TYPE CUBICLE SWITCHBOARD

such that it would mean shutting down the switchboard for a period when production is required.

We are indebted to Crompton Parkinson, Ltd., for the information contained in this article, and also for the photographs reproduced in the illustrations.

CLOSING OF AN IRISH RAILWAY.—The Northern Ireland Government proposes to close and wind up the Clogher Valley Railway, which runs 37 miles from Tynan, County Armagh, to Maguiresbridge, County Fermanagh, and is a 3ft. gauge line opened in 1887. The Government Bill providing for this states that a liquidator is to be appointed and he will sell all property and assets. Whole-time employees with more than two years' service will be entitled to compensation, and for those with at least ten years' service this will be an annual allowance of one-sixtieth of their remuneration for every complete year of service up to a maximum of forty years. Those with less than ten years will receive a gratuity of one-twelfth for every completed year. The Government proposes to meet all amounts payable in respect of dividends guaranteed on the share capital. The railway is at present under the management of a joint committee of the Tyrone and Fermanagh County Councils.

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THE MAINTENANCE OF TRADE

SOMEONE in the United States alleged that Great Britain was converting material received under the Lease-Lend Act into products which were being exported to overseas markets in competition with American goods. Whether that charge was made by opponents of the Lease-Lend Act or was a genuine protest by American manufacturers does not matter. In either case a definite assurance had to be given by the British Government that no such advantage was being taken of the Act. Mr. Eden therefore wrote to Mr. Winant, informing him that all materials which Great Britain obtains under the Act "are required for the prosecution of the war effort," and that the Government has taken and will continue to take action "to secure that these goods are not in any case diverted to the furtherance of private interests." Furthermore, he assured the United States Government that the British Government has "not applied and will not apply any materials similar to those supplied under lease-lend in such way as to enable their exporters to enter new markets or to extend their export trade at the expense of the United States exporters." He added that "Owing to the need to devote all available capacity and man power to war production, the United Kingdom export trade is restricted to the irreducible minimum necessary to supply or obtain materials essential to the war effort."

For some months after the opening of the war British manufacturers were encouraged and urged to maintain a fair portion of their export trade. That was done because imports from overseas had to be paid for. The passage of the Lease-Lend Act altered the position as far as the United States were concerned, but it left other countries just as they were. We still had, and have, to pay for what we purchase from them—the South American States, for example. We cannot afford to give up, and Mr. Roosevelt would be the last to expect us to give up, all our export trade because of the Lease-Lend Act. That Act was not passed solely for the protection of the United Kingdom; it has always been acknowledged that Britain is a bastion of America. Hence when the United States help the United Kingdom they help themselves. We are confident that the largest minds in America have no desire to use the Lease-Lend Act for the suppression of British export trade, and that they recognise our right and necessity to maintain that trade at as high a level as the circumstances of war will permit. Moreover, we must think not only of the present, but of the future. Some day the war will end and commerce between nations will be resumed. As a great industrial nation the United Kingdom must look forward to that time. Hence, to lose all contacts with her overseas markets would be a fatal mistake. Mr. Bremner has put this very wisely in a letter addressed to the members of the British Engineers' Association. "All men of vision and courage," he writes, "should think and prepare for the restoration of peace and the resumption of the forward march along both old roads and new roads which will have to be opened up. It is of vital importance to the future of the human race that we should cherish the spark of life in everything necessary or helpful to recovery from the destructive effects of the war and to progressive development thereafter. The restoration of international trade will be essential to the achievement of these ends. To concentrate wholly on the present, to ignore its implications with respect to the future, and to permit important parts of the complex and delicate organism of international trade to become moribund would be madness. The machinery of international trade cannot be completely stopped and then restarted at will. Inter-communication and inter-trade between as many as possible of the countries of the world must at all costs be maintained to the greatest extent practicable under the restrictive conditions of the war. To this end minds must continue to be furnished with the material for intelligent thought and action in the present and planning for the future. Eventually, home civil trade will also have to be restored and in the meantime it must be kept sufficiently alive to satisfy essential home civil requirements."

Trade and commerce in nearly every quarter of the inhabited globe have been dislocated by the war. A vast quantity of shipping has already been destroyed; ports have been bombed out of recognition; and roads and railways cut to ribbons. The struggle for the restoration of international trade will be a desperate one; far worse than that which followed 1918. On the rapid recovery of national industries the peace of the world will depend. If it is delayed riots, revolutions and civil wars will tread upon the heels of the disbanded armies. However deeply it may be felt that every effort must be expended upon the overthrow of the enemy, the nation that takes no thought for the years after the war, and makes no preparation for them, will assuredly place itself in a precarious position. True as it may be that not much can be done, yet what is possible should and must be attempted. To the Americas, to ourselves, to all European and Eastern countries it will be essential to re-open as rapidly as possible trade routes and markets. That cannot be doubted. Hence it follows that each of them, the United Kingdom no less than others, must endeavour by what power remains to it to maintain by all means available its contacts with other countries so that when the time comes trade may be restored rapidly and the terrible dangers of idleness and unemployment be avoided.

The Search for Lightness

WHEN many years ago Henry Ford took his very individual path to produce highly efficient civil aircraft, he gave his Detroit staff, so it is said, the single direction, "Simplificate and add more lightness." It is an aim by no means confined to aviation, which is merely the spearhead of the attack. It has, indeed, spread into most fields of engineering enterprise, and is likely to spread into all. The most obvious means of achieving lightness, though not the only one, is the use of such alloys of the lighter metals as dural, so extensively used in the aeroplanes of to-day, and even of ingeniously contrived reinforced plastics.

No one can yet foresee how far progress along paths such as this can be carried. Can anyone answer the question, What in the ultimate issue will be the limit of strength to weight? Indeed, is there any limit? A few men of science have been bold enough to attempt such forecasts. The argument is that since all materials are built up out of the same electronic raw material, and since in some cases the electric charges and the distances are known, it should be possible to calculate the strength of those materials which have a simple lattice structure. Computations have been made, and they reveal the remarkable result that even such common materials as glass and iron ought to be vastly stronger than they are. This was the conclusion reached many years ago by A. A. Griffith, and it has been confirmed by others since. It certainly surprised the engineers who first heard of it, who, though they would not have been startled to learn that there was a considerable divergence, certainly did not expect it to be so astonishingly wide. They thought perhaps that the difference would be similar to that between the theoretical air-standard efficiency of an internal combustion engine, of given compression ratio, and that achieved in practice—a ratio as large at one time as three or even four to one, but now approaching unity. But for the materials so far studied the strength ratio appears to be of the order of no less than 100 to one. In fact, the "efficiency" of current materials is only about 1 per cent.—lower even than that of the earliest heat engine. This result, whilst surprising, is most hopeful, for it gives the metallurgical engineer his opportunity, with all the elbow room he can possibly want. The first step towards the reduction of this immense gap is to discover how and why it exists. This has been attempted by several investigators, notably by G. I. Taylor, with his theory of "dislocation." One may make a precise calculation as to the aggregate force resisting rupture in a single group of symmetrically disposed molecules; if all such groups were alike, and all were pulling in the same way at the same time, a great force of resistance would result. But suppose that the drilling of the molecular army were not quite perfect, were, indeed, far from perfect, so that the forces engaged in something resembling a guerrilla struggle, then the aggregate strength in any one direction would be correspondingly less—as is found to be the case. This was well illustrated by some of the models used by Professor Andrade in his recent excellent James Forrest Lecture before the Institution of Civil Engineers. He showed graphically the contrast between well-drilled platoons of molecules and those which had somehow got out of step. It remains to discover how to give practical effect to some device for better discipline, for improved team work on the part of the molecules. If and when this proves possible of achievement, there will be a gain in the specific tenacity of common materials, which would have astonished our predecessors and which will transform the basis of all future engineering designs. Lightness of construction will be immensely aided once this advance has been made. We may then hope to see new alloys designed in much the same way as an electric generator is designed to-day, and with the same confidence in the result. This would be in the true line of development of what Mumford calls the "neotechnic" age, contrasted with the "paleotechnic" one in which most of us were brought up. In the newer age science is set to work from the beginning, and not merely used afterwards to explain why something happened; invention is less a happy idea, or a shot in the dark, than the outcome of planned team work; purpose is more related to general needs of the community than the making of profit for a few; national organisation is planned as carefully in days of peace as hitherto it has been in days of war.

When the new super-light materials come, their

influence will be immense, whether used for aircraft or for road and rail transport or for shipping. Their influence on the scope and range and speed of warfare may, indeed, be alarming, and prove so profound that more than ever will mankind have reason for maintaining peaceful relations throughout the world, no small test of human self-restraint being needed, since long experience has shown the danger that the first-fruits of every technical advance tend to be seized as an offering on the altar of the gods of war.

Obituary

ARTHUR THOMAS WALL

IT is with the deepest regret that we have to record the death, at his home, "The Hayes," Baring Road, Cowes, on Sunday last, September 14th, at the early age of fifty-five, of Arthur T. Wall, who, we may recall, retired about a year ago from the managing directorship of J. Samuel White and Co., Ltd., a position which he had held with distinction since his appointment in 1932.

Arthur T. Wall was born at Plymouth in 1886, and received his early education at Stoke and Plymouth, gaining King's Prizes in Science and Art. He continued his technical training at the Royal College of Science and at the Royal Naval College at Greenwich, where he was awarded the gold medal of the Liverpool Engineering Society and one of the premiums given by the Institution of Naval Architects. On leaving Greenwich he was appointed to Devonport Dockyard, from which he proceeded to the Thames Ironworks Company, Ltd., and took up the position of chief draughtsman. It was during Mr. Wall's time that H.M.S. "Thunderer," the last capital ship to be constructed on the Thames, was built. He was later appointed chief draughtsman of the Booth Steamship Company, Ltd., of Liverpool, a position he relinquished on his appointment as chief naval architect to Cammell Laird and Co., Ltd., at Birkenhead. During his long period of service with that firm he was engaged on the design of many Channel steamers and merchant ships, and the light cruisers H.M.S. "Chester" and "Birkenhead," which in 1914 were under construction for the Greek Government and were taken over by the Admiralty in 1915. He was responsible also for the design of the motorship "Fullagar," which was the first all-welded self-propelled ship to be built. He also prepared the first design of a ferro-concrete barge, which was approved by Lloyd's Register of Shipping. During the last war he was a member of the Lancashire Anti-Submarine Committee.

On leaving Cammell Laird's about 1923 Mr. Wall commenced business on his own account as a consulting naval architect in Liverpool, and later practised in London. In those years he was associated with the design and construction of many interesting ships for both British and overseas shipping companies. He was responsible for the design of the "Beaver" class of fast coal-fired cargo ships built for the Atlantic service of Canadian Pacific Steamships, Ltd. He also designed the "Lady Nelson" and the "Prince David" class of ships for Canadian National Steamships. In collaboration with Mr. James Dewar, he advised on the design and construction of the fast motor liners "Vulcania" and "Saturnia," built at Monfalcone for the Cosulich Line. In 1932, when Mr. Wall was called upon to take charge of the J. Samuel White Cowes undertaking, shipbuilding was practically at a standstill. Happily the succeeding years saw a revival, and he had the satisfaction of seeing during his period of management the fortunes of the firm rebuilt. Combining his long experience of naval architecture and the newly introduced art of welding, with a capacity for getting orders for new ships, whether naval craft, merchant ships, or yachts, from Governments, shipowners or yachtsmen, new construction was undertaken under Mr. Wall's leadership, and with the revival of naval shipbuilding the Cowes yard was, in 1938, probably as busy as, or busier than, it had ever been in its long history. Interesting ships with which Mr. Wall was personally associated at the yard were the two Polish destroyers "Blyskawica" and "Grom," both 2244-ton vessels with geared turbine machinery of 54,000 S.H.P., corresponding to a speed of over 39 knots. Other equally important orders were those for the two Brazilian destroyers "Javary" and "Jutahy," ships of 1340 tons, propelled by Parsons geared turbines with a designed output of 34,000 S.H.P. and a speed of 35·5 knots.

When, in November last, Mr. Wall decided to retire from the firm on account of ill-health, we expressed the hope of many friends that a period of rest would enable him to regain his health and again take up that work which he was so ably fitted to carry through. Unfortunately, as time went on there was no improvement. He died on Sunday last. The industry to which he gave so much can ill afford the loss it has sustained, and the death of Arthur T. Wall will be mourned by many business and personal friends, both in this country and abroad.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents.)

"PEACE AIMS"

SIR,—If I have understood Mr. I. V. Robinson correctly, his belief is that if there was any amount of money there would be no unemployment, and everyone could have everything he desired. Furthermore, if there was any amount of money no one would have to work for more than a few hours a day and everyone would have lots of time for intellectual and physical development. This happy condition is to be secured, on the Douglas principle, by concentrating the whole national credit in the Government. From that vast pool any one might draw to any extent. The Government would back all our bills and present us with Treasury Notes when payment fell due. Thus more and more money would get into circulation, and everyone who spent money, whether he worked for it or not, would be enriching the State by increasing the total volume of money—or credit—in circulation. To the unbeliever this looks perilously like inflation. If money was so easy to come by, its value would diminish and we should be caught fairly in the vicious spiral.

The alternative is the present system, which presumes that there is only a limited amount of money to go round. That amount is not fixed, but it increases only as fast as assets increase. The bank which lends money for the purchase of a new building does, admittedly, make money by a book entry, but opposite that entry has to be set a new building. The country is richer by that building, and therefore more money ought to be available. That is exactly the same as Mr. Robinson's—or Major Douglas's—proposal, but it is applied with restraint, so that inflation—the depreciation of exchange value—occurs very slowly; so slowly that adjustment to meet it can be made.

In passing, it is worth noticing what an absurdity the income tax has become now that it is collected at the source. The Government pays the wages and salaries, and then with the help of a vast staff and endless forms takes half of it back again! If the present method of collection continues, office staffs will require their salaries to be paid tax free, and the income tax will cease to be a poll tax. Individuals will lose their interest in it just as flat dwellers have lost their interest in local rates, which they do not pay directly. That means, obviously, that, for by far the larger part of the population, direct taxation, which in its day has been so much vaunted, will cease to be. The Government will virtually levy a tax on production, paid by the producer, not on incomes, paid by the salarian. This must have repercussions on our whole financial system.

To come back more closely to Mr. Robinson's proposals. They seem to me, like all kindred schemes, to rely far too much upon man's willingness to work without inducement in the form of reward in cash. It will be too easy to get what one wants. Even Henry Ford never went as far as that. He paid high wages so that his workmen might become his "best customers," but he did insist on hard work for those wages. As we know, his theory fell down in the end; it did not work out as he—and a great many Americans—expected. To pay high wages—or to give easy credit which is nearly the same thing—without equivalent effort would be still more disastrous.

Mr. Robinson seems to think that people dislike work. Many of us say we do; few of us mean it. Most of us are glad to have regular employment for the greater part of the day. We are like children in a playground; we get to quarrelling if we have not organised occupations. As for spending ten hours a day or so in intellectual development! Well, I ask you! Do our more popular newspapers give the slightest indication that the country wants to be intellectual? What was the true basis of the feminist movement? The right of women to work. They were bored at home, just as surely as the rest of us would be if we saw too much of it.

Mr. Robinson may take it from me that when Jehovah condemned man to work in the sweat of his brow, He did it as a set-off against the loss of Paradise. The world will be no happier when man can get all he wants by asking, when special merit or extra exertion does not receive exceptional reward, and when anyone who wants to work—for reward—for more than three hours a day is put in a lunatic asylum or a prison. ORTHODOCIAN.

Sixty Years Ago

LIGHTHOUSES

IN our issue of September 16th, 1881, we published the first of a series of articles entitled "Life Among the Lighthouses." The writer recalled the fact that for many years the maintenance of "private lights," outside the control of the Elder Brethren of Trinity House, provided a lucrative source of income to their proprietors. King Henry VIII and Queen Elizabeth laid the foundations of the Trinity House organisation, but although the Lord High Admiral Howard was compelled to surrender to the new body his authority with regard to "beacons, buoys, marks and signs for the sea," the private ownership of lighthouses was not completely abolished until Queen Victoria came to the throne. Even peers of the Realm—Lord Grenville was one—sought the King's ear for the right to set up and maintain a lighthouse on some barren rock. The nation and the mercantile marine paid heavily for Royalty's benevolence in this matter to its "well-beloved cousins and councillors." The lighthouse on the Smalls Rocks in the Bristol Channel was built by private enterprise by a Mr. Phillips, of Liverpool. The work was begun in 1772 under the charge of a young man called Whiteside, also of Liverpool, who had a strongly marked mechanical genius, although his real occupation was the making of violins, spinettes and harpsichords. With the help of some Cornish miners the structure was completed after great difficulties had been surmounted, and the proprietor settled down to enjoy the fruits of his labours. It is on record that the annual consumption of oil at the lighthouse was not more than 200 gallons, but every ship which passed within range of the light had to pay dues at the rate of twopence per ton. Sixty years later, when Mr. Phillips' representatives had to surrender the lighthouse to the Elder Brethren, they received £170,000 by way of compensation. In other instances sums of £300,000 and even £445,000 were paid to buy out the owners of private lighthouses. The first Eddystone lighthouse, completed in 1699, was built by private enterprise. It resembled a Chinese pagoda and was destroyed by a storm in 1703, all its occupants, including Winstanley, its designer, losing their lives. Rudyerd, a silk mercer of London, began a new lighthouse on the rock in 1706. About forty-six years later it was destroyed by fire. The existing Eddystone lighthouse constructed by Smeaton was, like the others, begun as a private enterprise.

BOOKS OF REFERENCE

The B.E.A. Handbook.—Despite the war, the British Engineers' Association has managed to prepare a fairly large edition of its Classified Handbook of Members and their Manufactures, and proposes to distribute it widely, both at home and abroad. The Handbook is an advertising medium, purely and simply, partly for the Association, but still more for the member firms and their products. It opens with an alphabetised list of the firms with their addresses, the addresses of their agents overseas, and some notes about their specialities. Then follow many pages of illustrated advertisements, and finally there is a Classified List of Manufactures of "B.E.A." Members. When we add that there are nearly 450 pages in the Handbook, its value as a work of reference for buyers will be at once recognised. In a foreword, Mr. David Bremner, the director, refers to the restoration of international trade after the war, and adds that far-sighted leaders of the engineering industry must spare time and thought to envisage and prepare for the future. "This means," he continues, "that we must think now about our future import and export trade, and of the adjustments that will be necessary to fit them, not only into the post-war framework, but to bring them into smoothly running gear with their counterparts in the various parts of the world." It is because the Handbook can do something to keep open the lines of industrial communications, both within our borders and across the seas, that it has been published at a time when the limitations of immediate trade are severe.

BOOKS RECEIVED

Mercerising. By J. T. Marsh. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 32s. net.

Air Navigation. By F. G. Brown. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 32s.

Social Energetics. Vol. 11. By S. A. Reeve. Pennsylvania: The Science Press Printing Company, Lancaster.

The Journal of the Institute of Metals. Vol. LXVI. London: The Institute of Metals, 4, Grosvenor Gardens, S.W.1.

Handbook of Workshop Calculations. London: H.M. Stationery Office, York House, Kingsway, W.C.2. Price 3d. net.

The Measurement of Flame Gas Temperatures

By Professor W. T. DAVID

THE measurement of the temperature of flame gases is of considerable academic and industrial importance, but up to the present no satisfactory method has been evolved, and indeed the temperatures given in the voluminous literature on the subject by skilled experimenters are often obviously seriously incorrect. It is the object of this article to suggest that the measurements as usually carried out cannot be expected to yield accurate results, and further to suggest what would appear to be a reliable method.

When accuracy is aimed at, the measurements are usually made either by the sodium line reversal method or by means of thin platinum wires (or thermo-couples) immersed in the flame gases, and these will first be critically examined.

Sodium Line Reversal Method

When combustible gas-air mixtures in varying proportions are burnt in a Bunsen burner the temperatures measured just above the inner cone by the sodium method are sometimes greater even than the ideally calculated temperatures. The sodium measurements by Jones, Lewis and Seaman[1] with propane-air mixtures are typical. These are shown in Fig. 1, together with the ideally calculated temperatures. It will be seen that both in the case of lean and very over-rich mixtures the sodium temperatures are greater than the calculated temperatures. The high temperatures obtained with the over-rich mixtures are usually attributed to the fact that the flames are totally

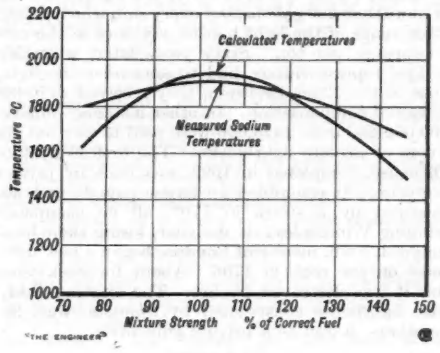


FIG. 1

coloured with sodium and that, therefore, the measured sodium temperature is influenced by those portions of the flame which are at higher temperatures than that corresponding to the mixture strength fed to the burner owing to infiltration of secondary air.[2] But such an explanation does not account for the high temperatures often observed with lean mixtures (as shown in Fig. 1). Nor really does it account fully for the temperatures on the over-rich side and, indeed, Minkowski, Muller and Weber-Schafer,[3] who made arrangements to colour the central portion of the flame only, found temperatures nearly 200 deg. Cent. greater than the ideal with over-rich mixtures. Furthermore, even with the ideal arrangement of a Smithells separator, Ellis and Morgan[4] found (as shown in Fig. 2) a temperature nearly 250 deg. Cent. greater than the ideal with a 50 per cent. carbon monoxide-air mixture.

It has been shown previously[5] that the explanation of the high temperatures obtained with both lean and over-rich mixtures is probably due to imperfect mixing of the combustible gas-air mixture fed to the burner. It will be clear that unless there is perfect mixing of the gases before combustion there will be small portions of them of higher calorific value than that corresponding to their mean strength. These, after combustion, will be at higher temperatures than the mean temperature, and in view of the fact that the intensity of the luminous radiation from sodium atoms increases very rapidly with temperature, they will exercise a very great—perhaps a dominating—influence upon measured sodium temperatures.

As is well known, precautions of a very complicated nature are necessary in order to obtain perfect mixing of gases—even in laboratory experiments—and it is certain it is never attained in practice. I think, therefore, that the sodium method of measuring flame temperatures is, in general, quite valueless.

An exception should perhaps be made when the combustible gas-air mixture is of such strength (generally slightly over-rich) as to yield the maximum flame temperature—unless, indeed, the mixture is so badly mixed as to be heavily stratified

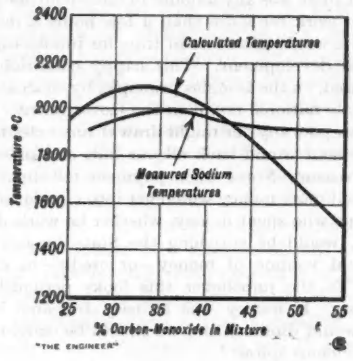


FIG. 2

—but even with such a mixture it is doubtful whether the temperature measured by the sodium method is not too high. It has been shown[6] that a long-lived latent energy exists in flame gases residing probably in abnormal molecules which are formed during combustion, and it is possible that the excess energy in these molecules is unloaded upon the sodium atoms during collisions, thus exciting them to higher levels. Furthermore, the introduction of sodium salts into the combustible mixtures may influence the nature of the combustion in such a manner as to cause higher temperatures in the flame gases after combustion than would have been attained in the absence of sodium salts. Dr. B. Pugh, working in this laboratory, has made some preliminary investigations upon the influence of sodium salts upon

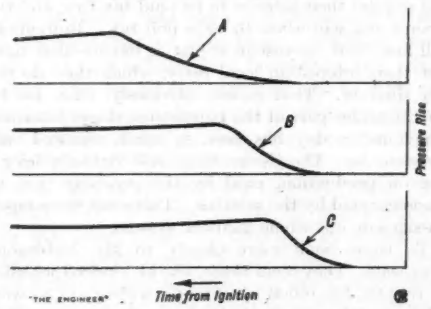


FIG. 3

carbon monoxide-air combustion which are most suggestive. Pressure-time records taken during the explosions of 45 per cent. carbon monoxide-air mixtures contained in an 18in. diameter spherical vessel are shown in Fig. 3. Curve A in this figure shows the rise of pressure when the carbon monoxide-air mixture was dry, curve B when the mixture was saturated with water vapour (by passing it into the explosion vessel through a tube containing water), and curve C when the mixture was passed through a tube containing a solution of sodium chloride. Comparison of curves B and C shows how marked an accelerating influence the sodium salt has upon the combustion of the carbon monoxide-air mixture. In a previous article[7] it was suggested that the latent energy in the flame gases decreased and therefore their temperature increased as the speed of combustion increased. It seems possible, therefore, that the introduction of a sodium salt causes the flame gases to have a higher temperature than they would normally have.

Summarising, it has been suggested that the sodium method of determining flame gas temperatures is possibly fundamentally unsound; but, however this may be, it is generally almost certainly valueless on account of the fact that the combustible air gases are never perfectly mixed in practice.

Platinum Thermometry

The flame gas temperature measurements about to be described were made by means of two types of thin wires. The first of these consisted of a platinum-rhodium alloy (10 per cent. rhodium) of 0·0005in. diameter, and the other a quartz-covered platinum wire of 0·0005in. overall diameter. It will, I think, be clear that the plain wire yields generally temperatures which are obviously very seriously in error—sometimes some hundreds of degrees Centigrade in error. The quartz-covered wire, on the other hand, yields temperatures which, after making allowance for radiation loss, appear to be correct. It will be obvious that, unlike the sodium temperatures, the wire temperatures give mean flame gas temperatures and are substantially independent of the degree of perfection of mixing of the combustible gas-air mixture.

The first series of experiments, which has been described in a former article,[8] were made during the pre-pressure (and therefore constant pressure) combustion period in large closed vessel explosions of mixtures of carbon monoxide and air of various strengths. They are summarised in Fig. 4. Curve T_P shows the temperatures measured by the uncovered platinum-rhodium wire and T_Q those measured by the quartz-covered wire. It will be noticed that except for very over-rich mixtures

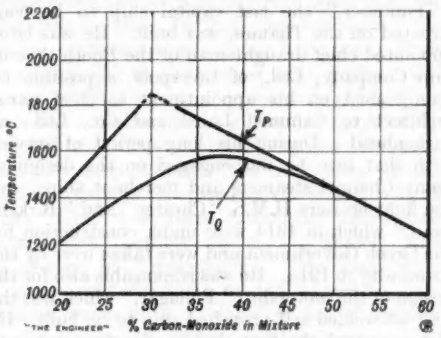


FIG. 4

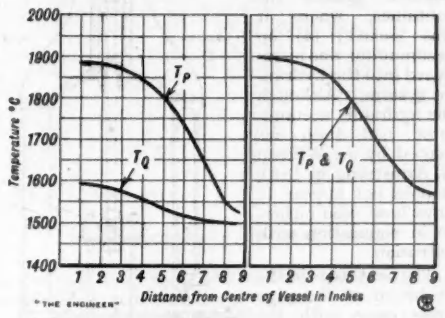
(50 per cent. carbon monoxide and over) the temperatures yielded by the two wires are widely different, the difference at the combining proportions mixture amounting to as much as 400 deg. Cent.

In the second series of experiments the temperature gradient along the radius of a spherical vessel of 18in. diameter was measured after the explosion (initiated by a centrally placed spark) of carbon monoxide-air mixtures—that is, at the moment of attainment of maximum pressure. The curves in Fig. 5 show the temperature gradients measured by the two wires when the mixture was a lean one consisting of 10 per cent. CO+7 per cent. H_2+83 per cent. air. It will be noted that the temperatures measured by the two wires are markedly different. The curves in Fig. 6 show the temperature gradient measured by the two wires after the explosion of an over-rich mixture consisting of 90·7 per cent. CO+1 per cent. H_2+8·3 per cent. O_2 in the same vessel. It will be noticed that in this case the two wires show exactly the same temperatures.

The results of both the first series (Fig. 4) an the second series (Figs. 5 and 6) of experiments are consistent in showing that for very over-rich carbon monoxide mixtures both wires yield the same temperatures, thus showing that the quartz covering has no appreciable insulating effect. But in all other mixtures—that is to say, generally speaking, the wires show very different temperatures. The first series of experiments were discussed at some length in a previous article,[9] and it is therefore unnecessary to discuss them further. It may, however, be pointed out that the discussion led definitely to the conclusion that the quartz-covered wire yielded, after correction for radiation loss, the correct temperatures of the flame gases which are assumed to be proportional to the mean

[1] *Journal*, American Chemical Society, Vol. LIII, No. 3, page 3993 (1931).
[2] Bauer, *Ann. de Chim. et Phys.*, Vol. 29, page 244 (1913).
[3] Lewis and von Elbe, "Combustion Flames and Explosions of Gases," Cambridge University Press, 1938.
[4] "Trans.," Faraday Soc., xxviii, page 826 (1932).
[5] *Engineering*, March 8th, 1940, page 241.
[6] *Phil. Mag.*, Vol. 23, page 345 (1937).
[7] THE ENGINEER, April 25th, 1941, page 268.
[8] THE ENGINEER, April 25th, 1941, page 268.
[9] THE ENGINEER, April 25th, 1941, page 268.

molecular translational energy of these gases. The second series of experiments led to the same conclusion. It has been found that for the weak mixtures the mean temperature of the exploded flame gases, as calculated from the uncovered platinum-rhodium wire temperature gradient, is much greater than that calculated from the measured maximum explosion pressure—even though no allowance has been made for radiation loss from the wire. The mean temperature of the exploded flame gases, as calculated from the quartz-covered platinum wire, is less than that inferred from the mean explosion pressure, but the difference may probably be wholly accounted for in terms of radiation loss from the wire; and the same is true for both the uncovered and the covered



FIGS. 5 AND 6

wire mean temperatures in the over-rich mixture (Fig. 6).

We thus arrive at the conclusion that for flame gases resulting from the combustion of carbon monoxide-air mixtures platinum thermometers (and probably also thermo-couples) cannot be expected to yield correct temperatures unless they are covered.

In the third series of experiments flame gas temperatures were measured by means of the two wires during the pre-pressure combustion of hydrogen-air mixture explosions, but owing to the rapidity of combustion of hydrogen mixtures only relatively weak mixturs could be employed. The results of the experiments are shown in Fig. 7. Curve T_P shows the temperatures attained by the uncovered wire. This curve was originally

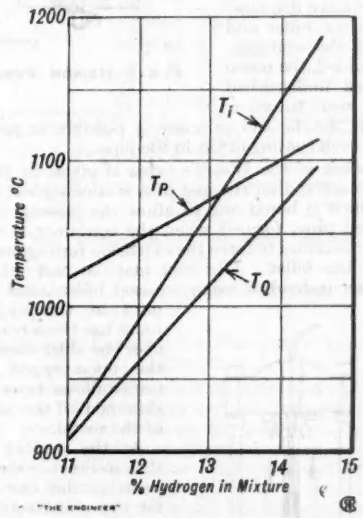


FIG. 7

obtained many years ago[10] and has subsequently been confirmed by two independent experimenters working in this laboratory. Curve T_Q, obtained by Pugh, shows the temperatures attained by the quartz-covered wire and T_i is the ideally calculated temperature. It will be seen that both the uncovered and the covered wires yield temperatures which are nearly the same for the strongest mixtures employed, but for weaker mixtures the plain wires yield much higher temperatures—temperatures which are indeed much higher even than the ideally calculated temperatures. This is a most interesting phenomenon and much work has been done upon it, which it is unnecessary now to describe. It may, however, be stated that an uncovered gold wire of the same diameter (0·0005in.) yields temperatures which are very approximately the same as the uncovered platinum-rhodium wire temperatures, and in view of the fact that gold does not appear to promote the combustion of hydrogen and oxygen upon its surface,[11] it would appear that the high plain wire temperatures are not due to incomplete combustion (as usually defined) in the flame gases. The quartz-covered wire temperatures curve bears, it will be noted, a reasonable relationship to the ideally calculated temperature curve.

The fourth series of experiments, somewhat similar in character to the second series described above, relate to the temperature gradient in exploded hydrogen-air mixtures. These experiments, which relate to a mixture consisting of 10 per cent. hydrogen and 90 per cent. air, are summarised in Fig. 8. Curve T_P shows the temperature gradient measured by a plain platinum-rhodium wire and T_i the ideally calculated temperature. The temperature gradient was not measured by means of a quartz-covered wire; indeed, the uncovered wire experiments were made

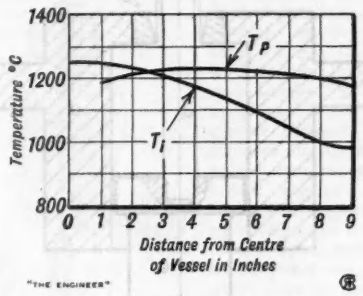


FIG. 8

many years ago and cannot claim the high degree of accuracy attained in the first, second and third series described above, but they are roughly correct. Certain correspondence with the curves in Fig. 7 may be deduced, and again they indicate that uncovered wires often measure something which is very different from what we usually regard as temperature.

[10] David, Davies and Jordan, *Phil. Mag.*, November, 1931, page 1043.

[11] Davies, *Phil. Mag.*, February, 1935, page 309.

The Channel Tunnel*

By ROLT HAMMOND, A.C.G.I.

THERE are few projects about which so much has been written and debated for nearly a century and a half than the Channel Tunnel. Ideas, fantastic and practical, have been put forward during that period in profusion, and a very brief history of these may be of interest at the present time.

It is generally believed that the first idea was put forward in 1802 by the French mining engineer, Mathieu, when he presented his plans to the Emperor Napoleon, during the First Consulship. The Emperor welcomed the scheme, which even found favour with the eminent British statesman, Charles James Fox; Mathieu's plans were exhibited at the Luxembourg and at other galleries in Paris, but it is unfortunate that no trace of them can now be found.

De Gamond was another French engineer who devoted a vast amount of time and energy to the solution of this problem. For more than forty years he studied various schemes, and considered in turn a submerged tube, a submerged concrete roadway, a train ferry and finally a tunnel. For building the submerged roadway he proposed to use forty submarine boats of his own invention; with these, and with the aid of 1500 sailors and navvies, for a sum of £10,000,000 he guaranteed to provide a Channel crossing lasting thirty-three minutes.

The Great Exhibition of 1851 gave rise to a crop of suggestions, most of which were fantastic and smacked more of the romances of Jules Verne than of practical engineering projects. In 1856 we find de Gamond once more on the warpath, this time with a proposal for a tunnel. He planned to build thirteen islands in the Channel, through which he would sink shafts to terra firma; from these shafts he proposed to drive tunnels east and west until the different sections met one another. At that time this was the only known method of driving long tunnels, for by such means it was possible to divide the work into sections of manageable length. The obvious objection to his scheme was the permanent obstruction which would be caused by the islands in the Channel, and it was therefore not surprising that the idea was rejected by Napoleon III and Queen Victoria, to whom it was presented simultaneously.

Undaunted by his failure to produce a workable scheme, de Gamond then turned his attention to the idea of a bridge, which he proposed to construct between East Ness Corner and Calais. This again would have entailed great obstruction to navigation, and any bridge project has the further disadvantage of being extremely vulnerable.

It is interesting from an historical point of view to mention that the bridge project put forward by Schneider and Hersant in 1889 received the support of such well-known bridge engineers as Sir John Fowler and Sir Benjamin Baker; details of the bridge were given at a meeting of the Iron and Steel Institute in Paris. Crossing the Channel from Cap Gris Nez to Folkestone, the longest spans were to be 1638ft. in length (as compared with 1640ft. in the case of the Forth bridge), while the shortest was to be 320ft. The columns of this huge structure were to rest on masonry supports, each 130ft. high, providing a minimum height of 180ft. above water level.

In the 'sixties and 'seventies of last century many suggestions were again put forward, one in particular creating considerable interest. This was due to James Chalmers, who published a book in 1861 in which he described his proposal for a submerged tube to be laid on the bed of the Channel, and to be ventilated by three huge towers rearing their heads above the sea. Obviously any form of submerged tube has grave disadvantages, for it would affect tides and currents very considerably, and probably cause considerable silting.

The year 1867 may be considered as the most momentous in Channel Tunnel history, for in that year William Low, M. Inst. C.E., conceived a plan of attack which has never been bettered, and he was the first engineer to put forward a scheme based on thoroughly sound engineering practice. Low was one of the best-known civil and mining engineers of his day, and carried out a large amount of railway and tunnel work. His scheme for the Channel Tunnel provided for twin tunnels, each 18ft. in diameter and 33 miles long, the submarine portion having a length of 24 miles. These two tubes were to be connected by transverse galleries at intervals of about 110 yards to help ventilation and the tunnel was to be located about 150ft. below the Channel bed.

Detailed plans for this scheme were presented by Low and G. F. Thomas to Napoleon II, in the same year, the Emperor being greatly intrigued by the ventilation possibilities of the twin tunnels. With typical Gallic wit he remarked: "I see perfectly; you give us English air through one tunnel and we shall send you French air through the other."

The formation of the Channel Tunnel Company in 1872 was followed in 1875 by a concession being obtained by the French Channel Tunnel Company from their Government, and a shaft was sunk at Sangatte, near Calais. From this shaft they subsequently drove a heading about 1½ miles in length and in the same year the South-Eastern Railway voted £20,000 for research. The Channel Tunnel Company also obtained powers to make trials at St. Margaret's Bay, near Dover. Low's plan for a railway tunnel was adopted by the railway company in 1881 and two shafts were sunk, one at Shakespeare's Cliff and one at Abbot's Cliff; from the former a 7ft. heading was driven for about 2000 yards, and from the latter a similar heading 880 yards long.

From all this it would seem that the great project was at last launched upon its course when, like a bolt from the blue, came a permanent injunction, sponsored by Mr. Joseph Chamberlain in 1882. Matters of national defence and high policy intervened to stop the venture.

Since that time the matter has been thrashed out from every conceivable point of view, but the author considers that there is only time to deal with the technical side of the problem, itself a fascinating study. Geologists have proved that the grey or Rouen chalk extends in a thick continuous bed across the Channel, and it is believed that there should be no insuperable difficulty in tunnelling through this material.

The Channel Tunnel Committee Report, presented to Parliament in 1930, is an extremely interesting document and worthy of close study. The Committee were assisted by three well-known firms of consulting engineers, who reached the conclusion that a pilot tunnel would be essential to prove the feasibility of the whole scheme; this would cost £5,600,000 and would take five years to construct. The main tunnels, which would be twin tunnels, as proposed by William Low, would involve the expenditure of £25,300,000 and would take another three years to construct and equip for an electric railway. After weighing all the evidence, which covered every aspect of the scheme, the Committee came to the decision that although some interests would be adversely affected, the Channel Tunnel would be of economic advantage to the country.

So the matter rests to-day, but at present we must obviously regard with the greatest suspicion, in view of recent bitter happenings, any project which tends to make us more vulnerable than we already are to unscrupulous gangsters who pretend to represent their countries. Let us hope that in the not too distant future it may prove possible to reconsider the scheme, but this will have to be in an atmosphere purged of traitors, parachutists and similar pests.

One of the most important points which occurs to the author is that it will be useless to incur this vast expense if the works have to be flooded in wartime. Under such conditions the whole effort and expense would go for nothing.

Finally, the author is convinced that this great work could be carried out and that if political conditions could be stabilised on the Continent, then it would be of irestimable advantage to all. Let us hope that such conditions will speedily come to pass, but this may be delayed for a long time yet.

* From "The Central," June, 1941.

The History of the Hydraulic Extrusion Process*

By C. E. PEARSON, M.A.

INTRODUCTION

THE extrusion process in its earlier stages could be applied only to a comparatively small number of soft metals and alloys of low melting point, and in practice was confined almost entirely to lead. The attractiveness of the method, from a commercial point of view, for the manufacture of lead pipes caused inventive skill to be focused specially in that direction, with the result that the history of extrusion during the first seventy or eighty years is largely a chronicle of the development of pipe making presses. With the rise of the electrical industry a fresh stimulus was given to the production of extrusion machines especially for sheathing cables. The inventions of Alexander Dick, made almost a century after the birth of the art of extrusion, brought about immense progress by rendering it applicable to some of the copper alloys. In the historical account which follows it has been necessary to select, from among the very large number of inventions and devices, those which appear to have contributed most, either directly or indirectly, to the various stages of evolution of the process, and either to omit or mention only in passing many which, though of intrinsic interest, have had little ultimate influence.

THE ORIGIN OF EXTRUSION

It is probable that the earliest perception of the principles of extrusion was due to Joseph Bramah, the famous hydraulic engineer, who, in a patent granted in 1797, described a press, shown in Fig. 1,

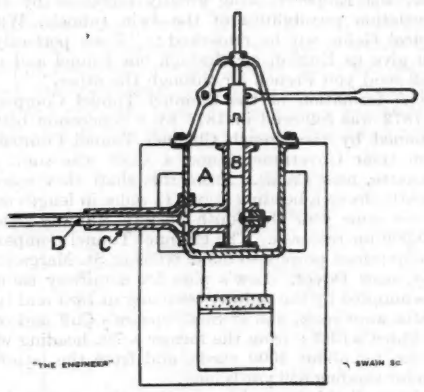


FIG. 1—BRAMAH'S LEAD PIPE MACHINE

"For making pipes of lead or other soft metals of all dimensions and of any given length without joints." Lead, maintained molten in an iron pot A by a fire beneath, was forced by a pump B into a long projecting tube C, which served as a die. A tapered mandrel D was supported concentrically with n the tube by means of a bridge in its enlarged end. The lead passing through the annular space between the tube and mandrel was kept molten by the fuel gases inside the outer casing until it approached the outlet where it was chilled to cause it to solidify so that it emerged in the form of a pipe. Though it is doubtful whether this apparatus, which, it may be remarked, was devised to make pipes for the distribution of beer and similar liquors, ever operated satisfactorily, it claims attention as providing the first record of a machine which embodies a conception of the idea of extrusion, while it contains, too, the germ of the idea of die casting.

EXTRUSION PRESSES FOR MAKING LEAD PIPES

There was no immediate development of Bramah's idea, and the earlier methods of making lead pipes by casting a hollow cylindrical billet, and either drawing this through holes in an iron plate or rolling it on a mandrel between grooved rolls, continued to be used, and it was not until 1820, when Thomas Burr, a Shrewsbury plumber, constructed a press operated by hydraulic power, that the manufacture of lead pipes by extrusion or, as it was then called, squirting, came into actual operation. Burr's machine, of which Fig. 2 is a sketch, consisted of a strong cylindrical container *a* secured to the top frame of a hydraulic press and having in its upper end a steel die *b*. The bottom end was sealed by a close-fitting plunger *c*, into which there was screwed a mandrel rod *d* and which was attached to the hydraulic ram. After withdrawing the plunger to the full extent lead was poured into the container through the die orifice and, following an interval for solidification of the metal, the hydraulic ram was operated to force the lead up through the die to form the pipe. At the end of the stroke the pipe was cut off above the projecting mandrel and hot lead was poured on to the remaining piece to melt it and clear the die. A difficulty was encountered, by no means unknown even to-day, in securing pipe of uniform thickness in its wall. This was due to the long mandrel bar becoming bent, so that it lay out of centre in the die, and recourse was had to wedging the tip of the mandrel in the die before filling the container.

By substituting a rectangular container provided with a slit aperture, Burr also made sheet lead. For this one side of the die aperture was formed by a plate, adjustable by means of screws, so as to allow sheet of different thicknesses to be formed.

A modified press was made by J. and C. Hanson in 1837, in which the lead container was made the

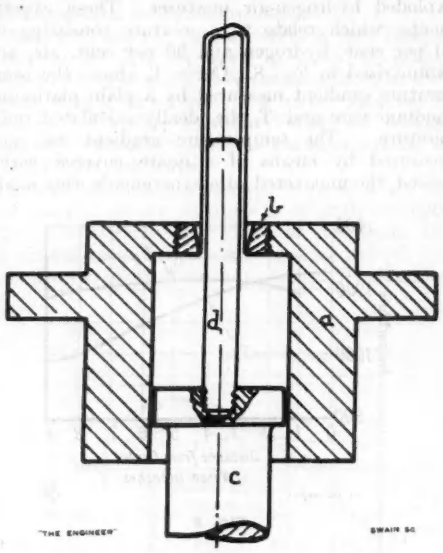


FIG. 2—BURR'S ARRANGEMENT

movable part by mounting it on top of the main ram of a hydraulic press, and a stationary plunger, attached to the head of the press frame, was used. The die was now fixed in the bottom of the container so that the awkwardness of the previous charging method was avoided, this being now done through a hole in the upper part of the container wall, which was sealed by the plunger at the beginning of the working stroke. Two features introduced to secure improved concentricity in the pipe, which, especially

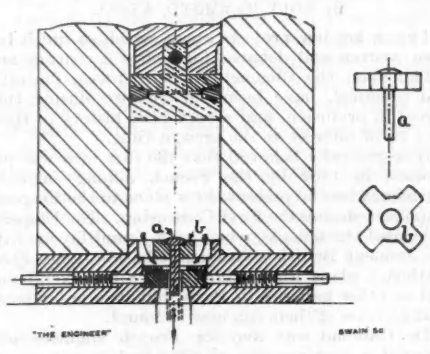


FIG. 3—PIPE PRESS, 1837

the first, are retained in principle in certain types of press to-day, consisted in a means of centring the die by four adjusting screws; and in the use of a primitive form of bridge die, by which the long mandrel could be replaced by a short one *a*, held in a support of cruciform shape *b*, over which the stream of lead divided to re-unite before actually entering the die. These arrangements are shown in Fig. 3.

The process of extrusion had become firmly established for the working of lead by the middle of the century, and the next noteworthy developments arose from the interest which was then being taken in the production of tin-lined pipes to overcome the danger of corrosion which occurs when lead pipes are used to convey certain waters and other liquors. In the first place, this had been accomplished by running molten tin inside lengths of extruded pipe, but in 1863 Shaw used a press in which pre-cast hollow billets of lead, with an internally cast sleeve of tin, as shown in Fig. 4, were charged cold into the container. Several billet presses of this kind were designed, but records show that very considerable difficulty was met in arriving at the correct shape of sleeve to give a uniform lining of tin in the pipe. This is not to be wondered at in view of the complexity of the flow which is now known to occur, especially in the direct method of extrusion, which was solely used at that time.

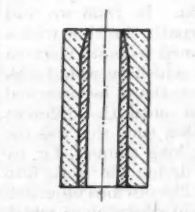


FIG. 4

A remarkable press for this work, invented in France by Hamon in 1867, which embodies many advanced features, is shown in Fig. 5. The principal points of interest are :—(1) The use of a fixed mandrel bar F, into which could be screwed points *r* of different sizes, over which the extrusion ram travelled; (2) the container B was made with ducts in its outer jacket, through which steam or hot gases could be circulated to raise its temperature to 210 deg. Cent. This provides the first example of the use of a heated container. Pointing out the necessity for careful adjustment of the temperature to avoid melting the tin sleeve, Hamon suggested the use of a pyrometer; (3) an auxiliary hydraulic ram R was used to bring the die O and die holder M into position against the container, where it was locked; (4) an accumulator was introduced into the hydraulic system. Although the hydraulic accumulator had been invented by Sir William G. Armstrong in 1840, it does not appear to have been used hitherto in connection with extrusion.

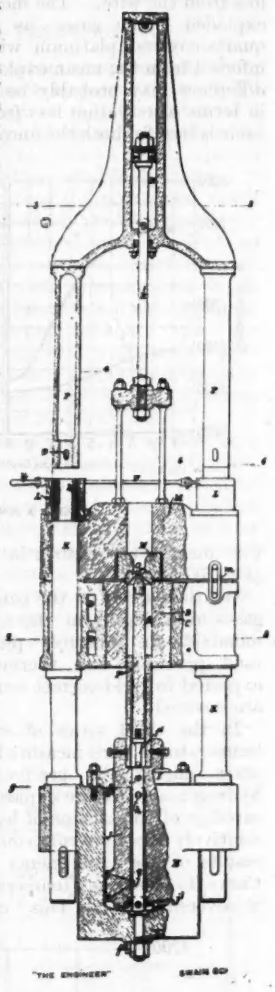


FIG. 5—HAMON PRESS

The next stage in the evolution of the pipe press came with the introduction by Haines and by J. and W. Weems, both in 1870, of the indirect or inverted method of extrusion. On the application of this method to copper alloys at a much later date it was shown to have the effect of so altering the course of deformation occurring in the billet as to obviate a characteristic defect in extruded material. This will be discussed more fully elsewhere but it is of interest here to note that the Weems, even at that time, claimed for the method that, since relative displacement of the billet and walls of the container was avoided, the metal remained undisturbed except near to where it enters the die and so made it possible to produce a more even coating of tin in the pipe.

A sketch of the Weem's press is given in Fig. 6. The die is fixed on the end of a stationary extrusion ram which is bored out to allow the passage of the extruded pipe, formed when the container is raised by the main ram to force the extrusion ram against the end of the billet. The lead may be cast into the container instead of using pre-cast billets, and when used in this way the press has the advantage over the older ones that the open-topped container allows dross to be skimmed off the surface of the metal.

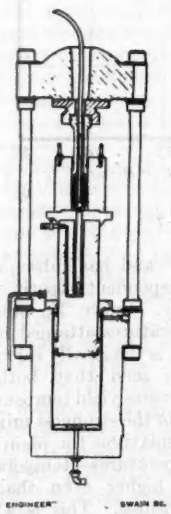


FIG. 6

At the present time the indirect extrusion press is the one used for the manufacture of lead pipes and improvements have been of detail only, so that the arrangement shown above is substantially that now in use.

Although the development of extrusion has hitherto been traced in connection with the lead pipe industry, since that was by far its most important application, some use of the process had also been made in the production of sheet and of special shapes, such as cames for leaded windows, by the use of dies of suitable form. For solid sections of simple shape multiple-hole dies were commonly used, the use of which for pipe making, though attempted, was not successful. Moreover, although lead was the metal chiefly used, there were extruded to a limited extent, in addition to the composite billets already referred to, other soft metals, such as tin and solder alloys and even zinc. A noteworthy offshoot of the main

* Newcomen Society, February 12th, 1941

line of development is provided by a series of ingenious devices for making, directly by an extrusion process, curved lead pipes for use as siphons, bends, or traps, which followed Cunningham's original patent in 1873. Two representative examples of these may be discussed. In Fig. 7 a casing B, containing a mandrel C and a sliding diaphragm A, was fitted to the end of an extrusion press. When the aperture of the diaphragm was centrally placed in the casing lead delivered by the press could be extruded through the orifice at D, forming the die, as a straight pipe; but by displacing the diaphragm laterally the supply of lead could be regulated so that a greater quantity passed

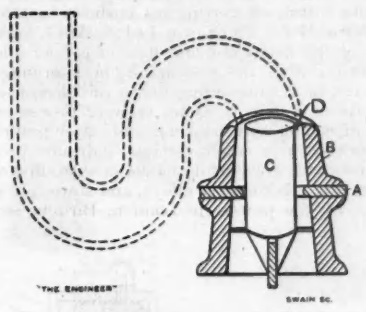


FIG. 7—EXTRUSION OF LEAD BENDS

to one side than the other, causing the issuing pipe to bend over to a desired curvature.

In an alternative machine, shown in Fig. 8, lead was poured into the cylinders A A of a steel casting, which were closed by two rams each connected with a hydraulic cylinder. The rams were advanced to force the lead, after it had solidified through the semi-circular passages B B in which partition fins C on the mandrel D kept the two streams of lead separated until just below the die orifice, where they united to form a pipe in the annulus between the die and the mandrel. By controlling the speed at which the hydraulic rams moved forward the operator could vary the rate of flow of lead on either side of the partition so that the greater volume passing through one side of the annulus produced a curved pipe, as in

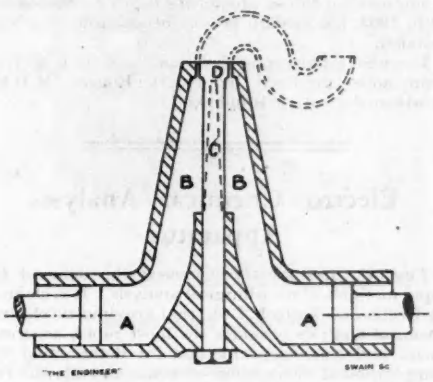


FIG. 8—EXTRUSION OF LEAD BENDS

the case above. Bend presses of the latter type continue to be in common use.

EXTRUSION PRESSES FOR SHEATHING ELECTRIC CABLES

The rapid development of the electrical industry in the second half of last century brought with it a need for a protective envelope for cables which would shield them against mechanical damage and be impervious to water. Lead suggested itself as almost the ideal material for this purpose, on account both of its pliability in facilitating the subsequent laying operations and of its relative immunity from corrosion. It had been used as early as 1845 by Wheatstone and Cooke in the form of a strip which was wound spirally round the insulated conductor, and finally soldered along the overlapped edges. Subsequently, cable was threaded through 50ft. lengths of ordinary lead pipe, which were then joined end to end by soldering. The cables were only loosely encased in this way, and required to be tightened up by drawing or rolling. In a further method a length of cable was laid out over rollers, with one end attached to the tip of the mandrel projecting through the die of a lead pipe press, and lead pipe was then extruded over the cable.

In 1879 there were devised by Borel in France and Wesslau in Germany the first methods by which a lead sheath could be directly extruded on to cables. In both cases vertical extrusion presses were used in which hollow cast billets of lead were extruded as a tubular sheath over an insulated conductor which was passed into the press through a hollow mandrel and issued through the tubular ram. Fig. 9 shows the general arrangement of the Borel press. With the ram F swung aside, a billet heated to 120 deg. Cent. was placed in the container P and extruded as a tube through the annulus between a die carried on the nose of the extrusion ram and the conical end of a mandrel tube G. The latter moved with the extrusion ram, being connected to it by means of a crosshead (not shown in the diagram). The conductor entered the press *vid* a bath of molten insulating wax, through the mandrel tube and passing thence inside the lead pipe as it formed, emerged through the hollow extrusion ram, running finally over a pulley R to the coiling drum. An illustration of this historically interesting press is given in Fig. 10. Although it worked successfully, it had the disadvantage that a continuous length of cable could not be sheathed owing to the necessity of cutting it to allow a fresh billet to be inserted, and while this could have been avoided by casting the charge of metal in the container, it was apparently considered impracticable because of the damage which the high temperature would have caused to the insulation where the cable passed through the mandrel during filling.

Two years after this there was brought out by Huber in Germany the press illustrated in Fig. 11, operating on the same principle as a lead bend press

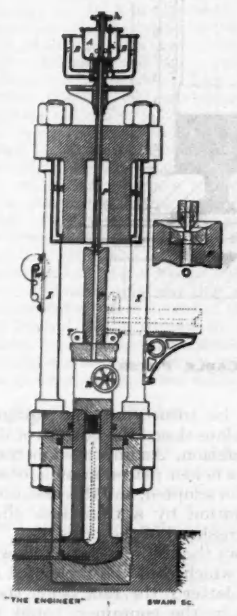


FIG. 9

already described above, to which its origin has been attributed, in having two hydraulic rams *a a*, Fig. 12, acting in cylinders opposite to one another, to force lead into a die block placed between them. Holders *c d* carrying the hollow mandrel or point holder through which the cable entered at right angles to the axis of the containers, and the die *f* and base ring *h* were screwed into the back and front of the die block respectively; both the point of the mandrel *e* and the die being replaceable to suit the size of cable which was required. In addition to the longitudinal adjustment by means of the screwed holder, the die could also be moved laterally by four wedge bolts *g* to afford a means of controlling the concentricity of the sheath. The two cylinders, heated by an oil-fired furnace beneath, were filled with lead through openings in their wall at a point furthest from the die block, from a melting pot set in a furnace on top of the press, after which the press rams were moved forward sufficiently to expel air and some of the dross carried in with the lead, and then seal the filling holes. When the lead had solidified the rams, set to provide equal pressure by an equalising valve, were operated to drive it round the point holder where the two streams met at the top and bottom of the latter, flowing forward subsequently through the die aperture as a sheath over the cable, which was thereby drawn through the press. These machines met with considerable success and found wide application at one time. By their means long lengths of cable could be sheathed without necessity for soldered joints, since consecutive charges of lead could be made into the container at the end of each extrusion stroke. Large units up to 5000 tons total pressure capacity were in operation by the beginning of this century and their use has only recently been abandoned. The chief difficulty which arose with them appears to have been in maintaining an even flow of lead from each container, due to small differences in temperature between the latter and thus of plasticity in the metal, so ensuring that two equal streams came together in the die block to form a closed sheath which was free from the danger of splitting along the weld seams.

Concurrently with the development of the horizontal press just described, there was evolved a vertical cable press, which had its origin in America

FIG. 10—BOREL PRESS

with the design in 1880 by Eaton, shown in Fig. 13, and which was adapted from the ordinary pipe press. A charge of lead cast and solidified in the container was made to flow circumferentially round a mandrel set transversely across the bottom of the container, and was extruded at right angles to the axis of the

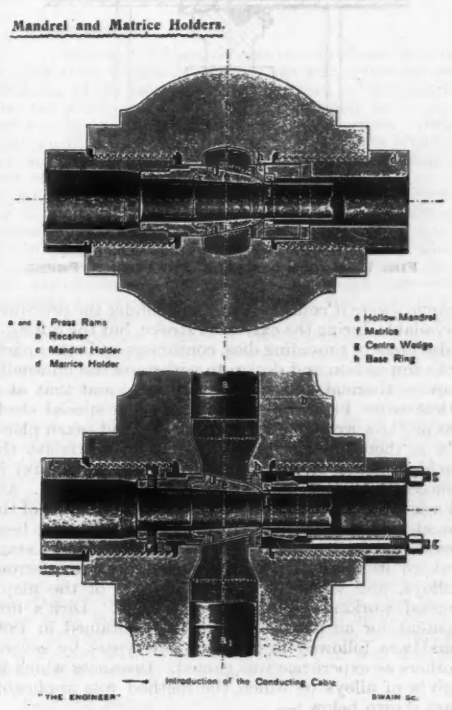


FIG. 12—DIE, MANDREL, AND DIE BLOCK

latter over a cable threaded through the mandrel. This press lent itself to the sheathing of long cables in the same way as the previous one. It was much improved in 1885 by Robertson, who made a special block to hold the die and mandrel, upon which the now separate container rested. The general arrange-

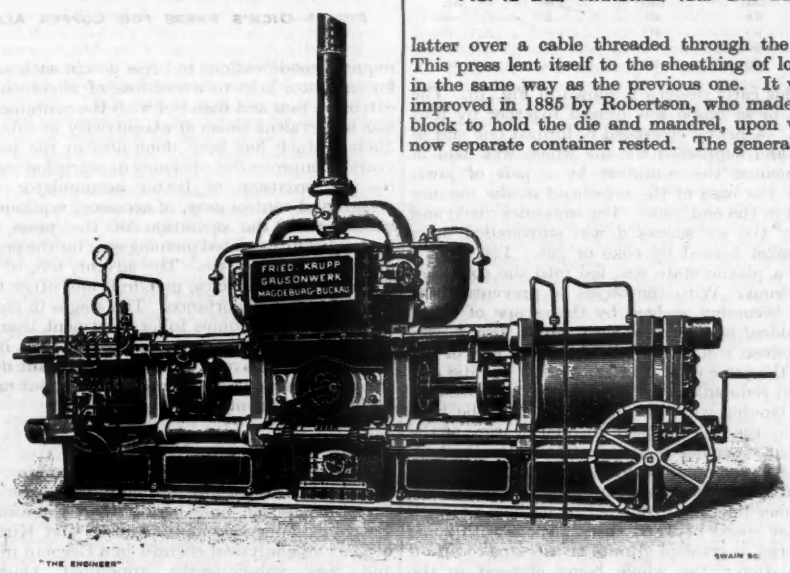


FIG. 11—HUBER CABLE PRESS. 1881

ment of the vertical cable press as it has evolved from this is shown in Fig. 14.

Application of Extrusion to Copper Alloys

The advanced state to which extrusion had been brought in the service of the lead industry and the manifold dvantages which it offered naturally directed attention to the possibility of its utilisation for other metals possessing better mechanical properties, such as the brass alloys, which, while much harder than lead at the ordinary temperature, were capable of being wrought when at a red heat. Records exist of several efforts to do this during last century, but the difficulties, at first, proved too great, and the lead presses which were, in many cases, used for experiment were unsuitable. A report of one trial states surprisingly that "it was anxiously and unexpectedly found that when the brass block came to be subjected to pressure the zinc left the copper, thereby producing a zinc pipe and leaving the copper behind, . . . proving that the atoms of brass composition, united by fusion, were only mechanically arranged, not chemically combined." The main difficulty as compared with previous practice was that even the brasses most susceptible to hot work do not become sufficiently plastic to undergo the heavy deformations involved in extrusion until they are heated to a temperature of at least 600 deg. Cent., so that the problem was by no means only that of providing a powerful press. Not only had the temperature of the metal to be maintained within the working

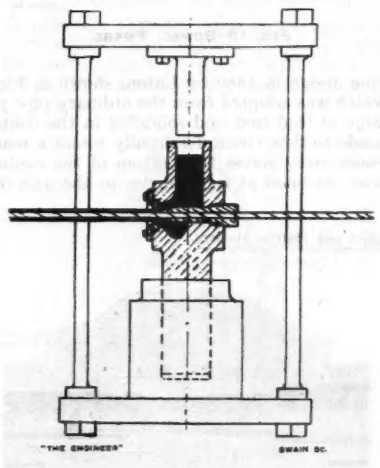


FIG. 13—EATON'S CABLE SHEATHING PRESS

range where it could be dealt with under the pressures available during the extrusion stroke, but the question also arose of providing dies, containers and other parts of composition and design to withstand the unusually severe thermal and stress conditions, and that at a time when little development of such special steels as are now available for such service had taken place. It is therefore hardly possible to overestimate the achievements of Alexander Dick (see Appendix) in successfully overcoming the obstacles involved. On his inventive genius has been laid the foundation of the modern hot extrusion process, which has now been extended far beyond its original limitations to a stage where it covers most of the technical non-ferrous alloys, and where it has become one of the major metal working processes in the field. Dick's first patent for an extrusion press was obtained in 1894 and was followed in the next few years by several others as experience was gained. Instances which he gives of alloys to which the method was applicable are shown below :—

	Cu.	Zn.	Fe.	Al.
1	58	40	2	—
2	85	10	—	5
3	90	—	—	10
4	60	40	—	—

One of his early designs is shown in Fig. 15. The horizontal press frame was braced together by four tie rods *a*. A heavy crosshead *b*, formed one end of the press and supported the die which was held in position against the container by a pair of jaws, pivoted at the base of the crosshead in the manner illustrated in the end view. The container *c* held and centred by the set screws *d* was surrounded by a furnace jacket heated by coke or gas. The billet *f* heated to a plastic state was fed into the container from the front. With the object of preventing the ram from becoming wedged by the escape of metal past its sides, a dished or corrugated disc *h* was placed between it and the billet. At the end of the extrusion the jaws were opened to allow the die and unextruded remnant to be pushed out. A persistent source of trouble was encountered in that the heat given up by the billet caused unequal heating of the thick-walled container so that it frequently cracked. To meet this, compound containers were introduced. One of the first of these, shown in Fig. 16, has a thin tapered inner liner *a* surrounded by casings *b b*, with the annular space between them packed with some such material as crushed granite or asbestos to afford heat insulation; the whole being encased in the strong outer shell *c*. The idea of this was that, although the inner liner became hot, it would suffer less damage from heat stresses than a thicker one and would, moreover, be easily replaced, while the outer shell being at a much lower temperature would retain its strength and therefore be capable of resisting the pressure. In addition, the heat of the billet being better maintained, it could be extruded much more readily. This construction did away with the need for external heating of the container, though it had to be warmed up to begin with by a gas burner or by inserting a hot block of iron. For a time, as an alternative to the use of preheated billets, the practice was also followed of casting the metal directly in the container, which was mounted for this purpose on trun-

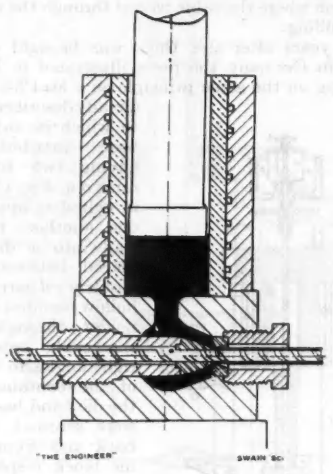


FIG. 14—CABLE PRESS

nions so that it could be turned into an upright position for casting. A plate closed the bottom of the container during this operation. An improved method of supporting the die in a holder placed in a die head, as seen in Fig. 16, was soon adopted, and this assembly was locked during operation by a transverse slide buttressed against the crosshead of the press.

The diagram also shows the use of a loose follower block behind the billet, which could be preheated so as to avoid cooling the latter; the ram being then made with a clearance in the container, could be readily withdrawn.

The production of rod and other solid sections was soon augmented by the manufacture of tubes from hollow cast billets, though considerable difficulty had to be met, owing to the inadequate steel available for the mandrels in keeping them cool enough to prevent breaking, and also in securing tubes of concentric bore. The early drawbacks of the hot extrusion process, limitation to comparatively simple shapes in few alloys, poor accuracy, and high scrap loss often exceeding 30 per cent., have only gradually been overcome. Some have been met by increased power and speed of operation of the press, others have

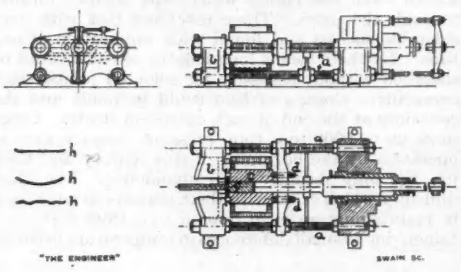


FIG. 15—DICK'S PRESS FOR COPPER ALLOYS

required modifications in press design such as would, for instance, help to avoid loss of alignment of the extrusion ram and mandrel with the container, which was a prevalent cause of excentricity in tubular products. Much has been done also in the past forty years to improve the efficiency of extrusion machinery by the provision of better accumulator systems, pumps and control gear, of accessory equipment connected with the operation of the press, and of hydraulically operated piercing gear for the production of hollow sections, &c. The advent, too, of chrome-tungsten steels for dies, mandrels and other tools has been of major importance. The stages in this subsequent progress require fuller treatment than can be afforded in a short survey, and, in any case, it may be said that they have involved no significant departure from the principles discovered by Dick, but rather the perfecting of his methods.

Appendix

George Alexander Dick was born in 1837 at Offenbach-am-Main, in Germany, his father being of Scottish descent and his mother English. After studying under Fresenius, Bunsen and Kirchoff, he became an analytical chemist in a German ironworks, and was subsequently appointed blast-furnace manager to a works in Spain. Later, with his brother C. A. J. Dick, he opened up a general engineering business in Paris, which was successful until the outbreak of the Franco-German war in 1870, when he settled in England, where, with others, he founded the Phosphor Bronze Company, of London, which he managed until 1881. For the next few years he devoted himself to investigating the possibilities of other copper alloys and to improving the brasses. The benefit of adding iron to brass had already been found by Baron Rosthorn in Austria, but difficulty had been met in introducing it into the alloys. Dick discovered that this could be done with certainty by the use of an iron-zinc alloy. He finally began the manufacture of some of these alloys under the name of Delta metal, converting his business in 1888 into the Delta Metal Company, Ltd. After making a study of the behaviour and flow of copper alloys in connection with the production of stampings and pressings, he became interested in the idea of making rods, tubes and sections by cheaper processes than those of rolling and drawing, and, after preliminary experiments in a small vertical hydraulic press, he was eventually successful in 1894 in extruding certain brasses and other copper alloys, and started to manufacture by the process in London, Birmingham and

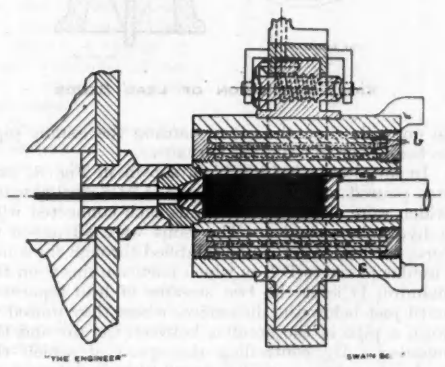


FIG. 16—DICK'S INSULATED CONTAINER

Düsseldorf. Upon his inventions, which he continued to improve up to the time of his death on September 18th, 1903, the modern process of extrusion has been founded.

The above biographical details have been derived from notes prepared by Henry Rogers, M.B.E., to whom the author is indebted.

Electro-Chemical Analysis Apparatus

THE war has greatly increased the demand for rapid methods of metallurgical analysis. It is claimed by Griffin and Tatlock, Ltd., that gravimetric electrochemical analysis provides the most rapid, accurate, clean, and convenient method for determining the composition of a wide range of metals and alloys. The use of the method is not confined to the determination of one metal only in a binary, tertiary, or other system. Many elegant procedures are available for the determination of one metal in the presence of others, including analysis by graded potential internal electrolysis, separations by complex-formation, micro-electro-chemical analysis, &c. The apparatus is basically simple, and, it is claimed, accurate results are rapidly returned. The speed of analysis is influenced by a number of factors. The following table gives some typical figures :—

Alloy.	Sample, grammes.	Total analysis time.
Al-Cu-Pb	3	1 h.
Pb in pure Zn	5–10	1½ h.
2 per cent. Cu	5	Cu 10 min.
Cu (high conductivity)	5	2½ h.
Brasses	2	½–1 h.
Bronzes (60–97 per cent. Cu+Zn +Ni)	1	Cu ½ h.
Ni-Fe-Mo+5 per cent. Cu	1	Cu 15 min.

The apparatus may be used to remove qualitatively from a solution metals having a coloured or otherwise interfering ion which hinders a subsequent operation.

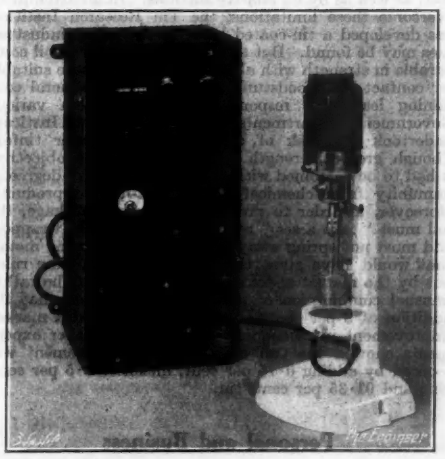
The accompanying engravings illustrate the two available types of a new apparatus made by Griffin and Tatlock, Ltd. One is a five-unit set for large-scale use, and the other a single unit set. It will be noticed that individual motors are provided for each electrode pair. Continuity of use in multiple units is thus assured should one motor fail. Each electrode pair in the rectifying system is electrically independent of the others, and is provided with its own rectifier transformer and controlling equipment. Electrodes are available in two weights, about 40 and 60 grammes per pair respectively. The heavier ones are recommended for routine use. The frames are stamped from sheet platinum and welded joints, which have proved in practice a source of weakness, have been largely eliminated. It also deserves pointing out that corrosion resistance has received great attention. Opal glass, vitreous enamel, ebonite, stainless steel, and rhodium plating are used on parts which cannot

be located in positions remote from the beaker where acid spray is liberated. Armour plate glass is used for the working shelf.

In the single unit a vitreous enamelled stand carries a similar pillar, about 14in. high, supporting a 1/30 H.P. acid and fumeproof ball bearing motor.

MULTIPLE UNIT APPARATUS

It has a stainless steel chuck with ebonite collets, and a glass paddle stirrer located in the inner of a pair of Fischer type platinum electrodes held in adjustable rhodium plated clamps mounted on the motor casing. The rectifier unit is suitable for wall or bench mounting. The transformer, with a primary tapped



SINGLE UNIT ANALYSER

200–250 volts for use on 50-cycle A.C. mains, is connected to a solenium type metal rectifier, capable of delivering up to 6 amperes D.C. at 12 volts. The multiple unit is generally similar, except for the differences that can be observed in the engravings.

TIN FROM TIN CANS

TIN, that strategic material of war which also protects so many of our foodstuffs from the corrosion of sheet iron cans, is the subject of much speculation to-day, both financially and mentally. Why not reclaim the thousands of pounds of tin that daily are coated on sheet iron, which, in turn, is formed into the familiar tin cans? This is a question that is often asked, the answer to which eventually may have to be used to solve a really acute shortage of the metal. At the moment, however, and until such time as financial considerations are overbalanced by need, the question may be answered simply: The process is too expensive.

As the tin situation now stands, and as it has stood for some time in the past, it is cheaper to throw away used cans and to fill requirements from new stocks. It has been estimated by a committee of the National Academy of Sciences that 12,000 long tons of tin—about one-eighth of our national needs—could be recovered annually from tin cans used in the United States. But, adds the committee, the overall cost of recovery would be high.

Many are the processes that have been proposed for reclaiming this bright metal which plays such an important part in our national economy, but so far none of them has proved practical from every standpoint. When one does come along that fills the bill, it will have a virgin field to work; in the meantime, or until the pinch of necessity forces recourse to expensive processes, city, town, and village dumps will continue to be the final resting-place for millions of pounds of tin.—*Scientific American.*

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Steel in India

According to *Foreign Commerce Weekly*, published by the United States Department of Commerce, the most important single influence on Indian economy during the first quarter of 1941 was the shipping shortage which hampered the outward movement of India's agricultural surplus and manufactures and sharply restricted the volume of imports. The general revival in domestic turnover after months of operation at a low level following the acute depression of mid-1940 extended to the first quarter of 1941. The sharp upward trend in industrial activity which has been evident since November, 1940, was further extended into the first quarter of 1941, during which some industries made new output records, notably the iron and steel industry, with an all-time high production of pig iron and steel ingots. There were few important developments in the field of industrial expansion, as the two vital bottle-necks of skilled labour shortage and machinery shortage continued to hamper Indian industries. A Machine Tool Control, modelled on the British Control, was established during this quarter, to regulate the utilisation of the available equipment. This action was necessitated by the increasing difficulty experienced in obtaining these goods from abroad, especially from Great Britain. Apart from the Machine Tool Control, few additional measures to regulate commerce or trade were introduced during the first quarter of the current year. Import trade restrictions came into operation, however, at the turn of the year which assumed control over imports of iron and steel, aluminium, and some other commodities. The Steel Control encountered a crisis when it became apparent that heavy orders placed in the United States before the end of 1940 were outstanding when the Control was instituted, but eventually most of these orders were licensed and subsequent business has been passing in a normal manner, subject to delays in shipping and in the American steel mills.

The Pig Iron Market

Pig iron consumers throughout the country will enter upon the winter months in a more satisfactory position than was the case for the two preceding years. The Control during the summer has encouraged consumers as well as producers to build up reserve stocks as a safeguard against the possible disturbance to traffic which sometimes occurs in the winter. Recently licences have been issued for the purchase of pig iron up to the end of the year, and few consumers now are not in a position to face a temporary delay in transport with equanimity. For more than one reason the import of pig iron from the United States is being curtailed. So far this does not appear to have had any adverse influence upon the position of consumers, and in view of the careful way in which the Control distributes pig iron supplies, it is probable that with the reserves they have accumulated, the pig iron consuming industries will be able to go through the winter with a moderate degree of comfort. Supplies of high-phosphoric pig iron are available in sufficient quantities to meet all calls made upon them, but the demand looks as though it were increasing, and as this class of iron is used for many purposes for which it was formerly regarded as unsuitable, the supply position may become somewhat tighter later on. Hematite iron is still scarce, and in this department the Control is keeping a tight hand upon distribution and licences are not issued unless the use of this description of pig iron is absolutely essential. Even under these conditions the production of hematite is wholly taken up, although there are indications that the output on the West Coast is overtaking the demand. The shortage of hematite has led to a greatly increased demand for refined iron, and some tightness is noticeable in this department. In Scotland the market is steady, and although all available supplies are quickly taken up they appear to be adequate to meet the demand. Some talk is heard that the price of Scottish foundry iron is not satisfactory to the makers, but it seems unlikely that there will be any change in price for a time.

Scotland and the North

The full production of the steel works in Scotland is passing into consumption, but there has been a slackening in the demand for certain descriptions of finished steel, and some of the works are able to give an earlier delivery than has been possible for a long time. The demand for plates is maintained at a high level and large tonnages are passing to the Clyde shipyards, which have a big programme of work in hand. Tank makers and wagon builders are also busy and are providing a good outlet for this class of steel. Structural engineers in Scotland are for the most part only moderately busy, and their requirements of heavy structural steel show little signs of increasing in the near future. The pressure to obtain light sections, however, is severe and all the re-rolling works are producing at maximum capacity. Although there has been a falling off in the imports of steel from the United States, as a result of the deliberate policy of the Control, the home production of semis has been extended, and so far the re-rollers, notwithstanding the busy conditions prevailing in that industry, have not had to draw upon the reserves they have accumulated during the summer to any extent. All marine and engineering establishments are fully employed, and are taking up large tonnages of bars, whilst their requirements of forgings and castings are heavy. A feature of the market continues to be the strong demand for alloy and special steels, and the production of these is upon a good scale. In Lancashire the demand for plates is the chief feature of the market, and there is no decline in this direction, although many users have been able to accumulate some stocks. There is a strong demand also for bars of practically all dimensions. The production of semis is on a heavy scale, and there is a particularly big demand for wire bars. Heat-resisting steels are also in active request. All the steel works on the North-West Coast are busy, and have good order books, and the production of bars, hoops, and rails continues on a steady scale.

North-East Coast and Yorkshire

Judging from statements which have been made lately, the position in the finished steel department is satisfactory in spite of the restriction upon imports from the United States. This situation, however, is only attained by the careful supervision of distribution exercised by the Control, and by the very drastic curtailment of the use of steel for civilian requirements. It is realised that the armaments, munition makers, and shipbuilders must have the first call upon steel of all grades, and after these are supplied, there is little left for ordinary commercial uses. A reassuring feature of the situation is that most of the re-rollers have been able to accumulate substantial stocks of semis, and these, with the current home production, should enable them to maintain their output at a high level. At the moment, the demand for some of the lighter descriptions of steel is more in evidence than for the heavier; the call for heavy joists and sections, for instance, has not recovered the vigour which characterised it earlier in the year, but big tonnages of the lighter sizes are passing into consumption. There seems a possibility, however, that the demand for structural steel will decline for a time, since many of the constructional engineers are not nearly so busy as they were, and there are few big contracts in sight. For some time now, the demand for alloy and special steels has been surprisingly heavy, and there is no indication of a decline in this direction. These steels are required for a large number of purposes connected with the war effort, and production has been pressed to the utmost. Large quantities of plates are still passing into consumption, although it is said that in some districts the volume of new business is not quite so pressing as a short time ago. In the Yorkshire district the demand absorbs the full output of the iron and steel works. There has been some change in the character of the demand, and although the larger proportion is for ordinary basic steel, there is an increasing call for special steels and nickel alloy steels. A steady flow of orders reached the plate mills from the shipyards, tank makers and wagon builders.

Copper and Tin

Although the copper position in Great Britain is satisfactory to the extent that the war industries are obtaining all the metal they require, there are indications that the world position is not so comfortable as it was, and this has naturally created some nervousness. Only small quantities of copper are being released for civilian requirements. Reports from the United States indicate that the copper position has become tight, and some apprehension is expressed regarding the future. According to the United States statistics, the stocks of refined copper in the United States at the end of August were 72,150 tons, a decrease of 2230 tons on the month. This is the lowest stock for some time, and apparently the difficulty of securing adequate supplies from the improved quantities available in South America is due to the difficulty of arranging shipping space. The result has been that the American Control is carefully supervising the allocations of copper. This is understandable, considering the quantities required for the United States rearmament programme, and apparently, as in this country, there is little copper available for ordinary commercial purposes. . . . The tin market has been firm of late for near positions. Possibly this may be in part due to the knowledge that the meeting of the International Tin Committee was to be held on September 16th. Although nothing official has been announced, it is understood that amongst the products supplied to Russia have been some quantities of tin. For some time past, smelters have been hedging when the price has risen above £260, but stopping these operations when the price fell below. As a result, it is possible they have accumulated some metal, and at the beginning of this week, when the price rose above £260, there was a fair amount of business transacted. The consumption of tin in Great Britain is believed to be only moderate. The stocks here are growing slowly, but no export licences are being issued.

Lead and Spelter

There is little change in the lead position in Great Britain, which, on the whole, remains comfortable. Apart from a demand from the building trade, which is well below normal, owing to restrictions upon building, the domestic consumption is maintained. The war industries are, of course, supplied with their full requirements, and to a certain extent metal is made available for some commercial purposes. In the United States the position is much easier than it was, as a result of the large imports of foreign lead, and the principal complaints now are of the difficulty of obtaining deliveries when required, owing to transport delays. According to the American Bureau of Metal Statistics, the stocks of refined lead in the United States at the end of June were 19,250 short tons, compared with 29,080 tons at the end of May. . . . An active demand exists in Great Britain for spelter, the principal consumers being the firms engaged upon war work. The brass industry continues to take large quantities, but, on the other hand, the galvanising industry, which is quieter than it has been for a long time, is providing only a moderate outlet for the metal. In the United States the position is still stringent, although it is anticipated that it will become easier as a result of an increase in the American production. According to statistics published in the United States, the domestic zinc output during August was 75,500 tons, compared with 66,400 tons in July. Deliveries in August were also higher at 71,400 tons, compared with 64,000 tons in the previous month. At present consumers in the United States appear to be rather worried about the future spelter position, but at the same time it is anticipated that there will be a further increase in production this year. There is, of course, no spelter available for export from the United States, and the home distribution is carefully supervised by the Control.

Notes and Memoranda

Rail and Road

THE CLOGHER VALLEY RAILWAY.—It is reported that the Northern Ireland Government proposes to close and wind up the Clogher Valley Railway, which runs from Tynan, County Armagh, to Maguiresbridge, County Fermanagh, a distance of about 30 miles. It is a 3ft. gauge line, and was opened in 1887.

SLEEPERS.—Germany is to build sleeper cars with four single-berth first-class compartments, and ten single-berth second-class, the vehicle thus accommodating fourteen passengers in all. The older sleepers on the line concerned accommodated eleven passengers first-class and as many second, or twenty-two of the latter class.

PLASTIC MOTOR-CARS.—It is reported that Mr. Henry Ford has produced experimentally his first plastic motor-car. Only the frame, the engine, and the wheels are metal. The weight of the experimental car is 2000 lb., two-thirds that of a steel car of the same size. The panels, although only $\frac{1}{4}$in. thick, can, it is claimed, take a blow ten times harder than can steel without denting.

MOTOR VEHICLE LICENCES.—The Minister of War Transport invites motorists to make early application for renewal of motor vehicle licences, which expire on September 30th. Applications can be made any time after September 16th. Those wishing to surrender an annual licence for refund are reminded that they must post before midnight on September 30th. Handing in a licence at the Council's office on October 1st will invalidate the claim.

A "STOP" ROAD SIGN.—Vancouver, B.C., is experimenting with a new type of ribbed street stop sign, invented by a local sign painter. It is about 2ft. square, of parallel triangular ribs projecting only 1in. above the pavement. The word "Stop" is painted in an "elongated" manner on the sides of the ribs. Viewed by an approaching car 50 feet away, the lettering stands up as if on a vertical board. The experimental sign is made of metal, but signs for service could be made of rubber with the lettering inlaid.

A HUNDRED YEARS OF C.O.D.—The *Railway Age* of America has pointed out recently that C.O.D. was instituted a hundred years ago as American railway practice. The story goes that a New York merchant went into the Broadway office of Harnden's Express Company, which had been established by William F. Harnden two years earlier, and placed a package on the counter, saying, "I want to have this sent to my customer at Fulton, in Oswego County, but don't let him have it until he pays 16.50 dollars. If he does, send the money to me, and I will pay you for the service." Harnden agreed and the deal was carried out successfully. Thus, in 1841, was actually established C.O.D.

LONGER VEHICLES DURING WARTIME.—The Ministry of War Transport has announced that it is proposed to amend the regulations relating to vehicles drawing trailers, and that all vehicles up to 30ft. in length would be permitted to draw trailers. The present stipulation provides that no vehicle exceeding 26ft. in length may draw a trailer. Under the new concession the combination of vehicle, drawbar, and trailer must not exceed 60ft. in length. The maximum laden weight of vehicle and trailer is increased from 22 to 32 tons on condition that the trailer is equipped with power-assisted brakes which can be operated by the driver of the drawing vehicle. The concessions are to be discontinued at the end of the war.

NEW MISSOURI STREAMLINED TRAINS.—The Missouri Pacific Lines administration has placed an order with the Budd Manufacturing Company and the Pullman Company for two new oil-engined streamlined trains, to be added to its existing "Eagle" fleet. Delivery is expected before the end of this year. Each train will consist of a mail storage car, a mail and baggage car, and a baggage express car—all 70ft. vehicles, a stainless steel grill buffet car containing a compartment for the dining car staff, a number of *de luxe* coaches with women's and men's lounges and lavatories, and a dining lounge car measuring 82ft. overall. In this car there is to be a fully equipped kitchen with all the latest electric services and conveniences, a twenty-four-seater dining compartment occupying the central 20ft. of the car, and a 26ft. lounge compartment in rear.

THIRD CLASS ONLY TRAINS.—The Minister of War Transport has announced that from Monday, October 6th, all trains which both begin and end their journeys within the London Passenger Transport Area, extended to certain points somewhat beyond that area, will be third class only. First class accommodation will continue to be provided in trains beginning or ending their journeys outside, but making stops within, this area. This decision has been taken to meet the wartime difficulties of workers travelling daily in and out of London where the concentration is greater in number and in time than in any other City and where the journey home is longer. Approximately 5000 trains are involved, and as a rough guide the area includes Bletchley, Bedford, Hitchin, and Bishops Stortford in the north, Witham, Upminster, and Gravesend in the east, Sevenoaks, Horsham, and Guildford in the south, and extends on the G.W.R. to Reading in the west.

Air and Water

AMERICAN AIRCRAFT OUTPUT.—The United States Office of Production Management has announced that military aircraft manufacturers delivered 1854 machines in August, an increase of 394 over July and the highest total for any month of 1941.

NEW SWEDISH MOTORSHIPS.—In the middle of August the Swedish shipyard, Oresundsvarvet, delivered a modern motor fruit carrier of 3090 tons deadweight to the Stockholm shipowner, Sven Salen. The vessel, which bears the name "Sandhamn," after the internationally known yachting centre on Sweden's east coast, is propelled by four five-cylinder two-stroke engines, developing 4500 I.H.P. At the trials a speed of 17 knots was attained. The vessel is intended for carrying bananas between the West Indies and Sweden. Owing to the war it has had to be laid up.

BACK AT WORK.—In the Norfolk Navy Yard the U.S. Admiralty has a power shears with which the plates for the ss. "Merrimac," of Civil War fame, were trimmed and punched in the yard in 1860. Although retained as a museum piece, it has been motorised and is still used occasionally for cutting bolts and rivets.

WELDED PIPE PILES.—The footings of the aircraft engine factory built by the Ford Motor Company at Dearborn, Mich., entailed the driving of 3500 tons of spiral-welded steel pipes. In all, 45 miles of these pipe piles were needed for 500 building footings. The pile drivers worked on the top 50ft. lengths of the 100ft. piles, after welders had joined them to the bottom lengths.

THE PORTLAND AND MONTREAL PIPELINE.—A pipeline for crude oil, begun simultaneously in the United States and Canada, has been joined by welding near Highwater, Que., on the border between the United States and Canada. The line is a 12$\frac{3}{4}$in. steel pipe which will carry 50,000 barrels of crude oil per day from Portland Harbour to Montreal refineries, and thus save ten to twelve days of travel by tankers.

NEW ALUMINIUM PLANTS.—To meet the ever-expanding demand for aluminium, the U.S. Office of Production Management has initiated a fresh programme of new works. The sites selected for the new plants are in Arkansas, Upper New York State, Alabama, California, North Carolina, and Bonneville (Grand Coulee area). All will be Government-owned, but privately operated under lease agreements.

ANOTHER TOWER MOVED.—America would always move a structure rather than dismantle and re-erect it. Shawneetown, Ill., had recently to be rebuilt 3 miles above a flood area on the Ohio River, and the evacuation involved the transport of an 80,000-gallon tank, 132ft. high, and weighing 60 tons, complete with its 36in. steel riser pipe. After packing on an eight-wheeled trolley, two caterpillar tractors did the hauling. At one point a railway track had to be traversed.

A WATER BATTALION.—A water supply battalion, the first organised in the U.S. Army since the 1914–18 war, has been formed at Camp Livingston, Louisiana, as part of the Third Army. The unit, the 80th Engineer Battalion, Water Supply, will consist of a battalion headquarters, headquarters and service company, three lettered companies, and attached medical personnel. Its strength will be 19 officers and 407 enlisted men. To carry out its function of water supply within the field army, the battalion will be equipped with nine mobile water purification trucks and ninety 750-gallon tank trucks, together with other motor vehicles for administration.

AMERICAN MERCHANT SHIPS.—Four "C-3" passenger and cargo ships building for the United States Lines at the Ingalls Shipbuilding and Drydock Company's yard have recently been named. Names have also been chosen for another "C-1 B" building for the Alcoa Line, for two of this type under construction for the Pacific and Atlantic Steamship Company, four "C-1s" recently acquired by the Navy, and for two "C-3s" building for the Army. Those building for the United States Lines have taken the names of former American merchant liners that were put under the Belgian flag and transferred to a Belgian company shortly after the war started. All but two of these have been sunk. The first of the new ships will be called the "American Merchant," while the three others are "American Farmer," "American Banker," and "American Shipper." They are designed for the Trans-atlantic service of the United States Lines, when this can be resumed. The new Alcoa ship will be named the "Alcoa Pennant," while the "Cape Clear" and the "Cape Douglas," recently assigned to the Pacific and Atlantic Steamship Company, will retain their names. Two "C-3s" under construction for the Army at the Seattle-Tacoma shipbuilding yards will be named the "Frederick Funston" and the "James O'Hara." A "C-1A" recently acquired by the Navy and originally called the "Cape Lookout" has been christened the "Fomalhaut."

Miscellanea

RECORD TANK OUTPUT.—The Minister of Supply has sent a telegram to all factories manufacturing tanks and tank parts congratulating them on their record August output. The number of heavy tanks produced was double that for the month of March.

BELGIAN CONGO INFORMATION BUREAU.—Under the auspices of the Belgian Ministry of Colonies, the Belgian Congo Information Bureau has been established as a separate department of the Belgian Chamber of Commerce in London to assist exporters of British goods. The address of this Bureau is 8, Union Court, London, E.C.2 (telephone, London Wall 4424).

ASBESTOS IN W. AUSTRALIA.—The Assistant State Mining Engineer of Western Australia has reported, after an inspection of the Hamersley Range blue asbestos deposits, that exposures were located at various points over a distance of more than 120 miles. There seems a possibility of the existence of hundreds of square miles of productive country. Roebourne is the port nearest to these potential mines.

HARD CHROME PLATING.—A contributor to the *American Machinist* has recently discussed the need for rapid and accurate methods of measuring the thickness of deposits. It has also been found advisable to devise tests wherein the nature and quality of various electroplated metals, including chromium, may be determined without undue expenditure of time. After describing a number of methods, the author goes on to explain the Amineo-Brenner Magne-Gage, an instrument devised in the laboratories of the U.S. General Electric and Ray Corporation, with which the thickness of chromium plating on any magnetic part of the plated tool or article can be determined without damaging the surface.

BUILDING MATERIAL.—Lord Reith, speaking at a luncheon recently, said that there was no longer a shortage of bricks. They had an eight weeks' reserve of cement, and an output of 150,000 tons weekly, and a programme that was twice the building industry's capacity to handle. His Department was dealing with £1,000,000 worth of building work per day.

MINING MACHINERY AND PLANT.—Under the Machinery and Plant (Control) Order made by the Board of Trade and dated September 11th, 1941, a general licence has been issued permitting the supply of machinery, plant and appliances of certain specified kinds to mining undertakings where the authority of the Mines Department of the Board of Trade has been obtained for the acquisition of any such goods.

COMPLETION OF THE CARLTON TUNNEL.—The 6-mile Carlton tunnel project at Cripple Creek, Colorado, was officially completed on July 25th. Work on the tunnel has involved the removal of 180,000 cubic yards of Pike's Peak granite, which required the use of over 10,000 lb. of explosive. The average daily advancement was 48$\frac{1}{2}$ft. The tunnel was driven to dewater the mines of the Cripple Creek gold-mining district, and some of the mines are already free from water, while others are rapidly draining. This dewatering started on February 19th, 1941, when the New Market fault was encountered and water ran from the portal of the tunnel at the rate of 20,000 gallons per minute. *Engineering News-Record* states that the million-dollar project was started on July 13th, 1939, when it was thought that four years would be necessary to complete the job.

IMPROVED TINFOIL.—A note in the August issue of *Tin* refers to the necessity in present circumstances of restricting supplies of aluminium to war uses, and the need for an alternative material for the manufacture of foil, in particular for milk bottle caps. An ideal metal for use in contact with foodstuffs is tin, but the extent to which ordinary tinfoil can be used commercially is limited by its cost, as well as by its relative softness. In an attempt to overcome these limitations, the Tin Research Institute has developed a tin-coated lead foil for which industrial uses may be found. But the real need was for a foil comparable in strength with aluminium foil and more suitable for contact with foodstuffs than a composite metal containing lead. In response to requests from various Government Departments, the Tin Research Institute undertook the task of discovering a stronger tinfoil. Though greater strength was the immediate objective, it had to be combined with ductility and a high degree of immunity from chemical reaction with food products. Moreover, in order to provide an air-tight package, the foil must "take a set" round the object to be wrapped, and must not spring away. Many of the alloying metals that would have given the desired strength were ruled out by the matter of toxicity, but a study of the rather unusual combination of tin and zinc disclosed that the addition of 8 per cent. of zinc to tin effected a marked improvement in mechanical properties. Further experiments showed that an even greater improvement was secured by adding 0·15 per cent. nickel to 8·5 per cent. zinc and 91·35 per cent. tin.

Personal and Business

MR. D. C. BULLOCH has been appointed London director of Wm. Riddell, Cousland and Co., Ltd., of Glasgow.

MR. A. N. WILLIAMS, president of the Lehigh Valley Railroad, has been elected president of the Western Union Telegraph Company.

G. AND J. WEIR, Ltd., announce with regret the death on September 6th of Mr. James P. Anderson, manager of the land installation department of their London office since 1929.

MR. E. A. F. JOHNSTON, whose services have been lent to the Ministry of Aircraft Production by the London Passenger Transport Board, has been appointed Assistant Director of Aircraft Production Factories.

WE note with regret the death, at the age of seventy-six, of Mr. Robert Haswell, managing director of William Doxford and Sons, Ltd. He was a Vice-President of the North-East Coast Institution of Engineers and a member of the Worshipful Company of Shipwrights.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Institute of Fuel

Wednesday, Oct. 15th.—Connaught Rooms, Great Queen Street, Kingsway, W.C.2. Presidential address, "The Hundred Thousand: An Engineer's Philosophy," W. M. Selvey; and Melchett Lecture, "Recent Progress in Coal Petrology," C. A. Seyler. 2.30 p.m.

Institution of Electrical Engineers

Saturday, September 20th.—N. MIDLAND STUDENTS' SECTION, Visit to X-ray department of Leeds Infirmary. 2.30 p.m.

Institution of Mechanical Engineers

To-day, September 19th.—Grosvenor House, Park Lane, W.1. Luncheon. 12.45 for 1.15 p.m.

Saturday, September 27th.—YORKS BRANCH. The University. Leeds. "Combustion, Detonation, and Turbulence in Petrol Engines," W. T. David. 3 p.m.

Friday, Oct. 24th.—Storey's Gate, Westminster, S.W.1. Presidential address, "The Position of the Locomotive in Mechanical Engineering," W. A. Stanier. 2.30 p.m.